Metallurgical Features of British Industries Fair

OF the many metallurgical features exhibited at Castle Bromwich, the character and variety of ferrous and non-ferrous alloys were not the least important. The rapid progress made in various branches of the engineering industry during recent years has placed an increasingly heavy tax upon the skill and resourcefulness of the metallurgist. The quality of the materials supplied must reach a high standard in order to meet exacting requirements, and in no metallurgical section is this more exemplified than with case-hardening steels. The specification limits with regard to all steels have been narrowed down and tests rendered more severe, but it is uniformity of quality that is very necessary, particularly in regard to case-hardening steels. Until recently, manufacturers were confined to various makes of free-cutting steels, which were lacking in strength, and ordinary case-hardening steels which made little or no claim to machinability. There are now, however, many special case-hardening steels produced in this country which have been tested and used long enough to prove their merits. It is true that the success of the case-carburising operation depends to some extent on the skill displayed in the operation, but the subsequent behaviour of the cased steel depends largly upon the quality and character of the original steel.

Case-hardening Steels.

There is a demand for a steel which will machine well at the high speeds of modern automatics and is not brittle or unsuitable for case-hardening purposes. A number of firms are devoting considerable attention to the subject, and are specialising in the production of case-hardening steels. The British Rolling Mills, Ltd., have an interesting record in this connection and exhibited many different kinds of case-hardening steels, two of which are of recent origin and which have characteristics worthy of note. One is a free-cutting steel, known under the brand Brymill C.H. 2, from which an average sample taken from a standard $1\frac{1}{8}$-in. diameter test-piece, after double treatment, gave the following result :—

Ultimate stress	35 tons minimum per sq. in.
Yield	23 tons minimum.
Elongation	30% on 2 in. minimum.
Reduction of area	55% minimum.
Izod impact	60 ft.-lb. minimum.
Torque at elastic limit	11·4 tons per sq. in.
Maximum torque	2,080 in.-lb.
*Maximum twist	1,840°
Maximum stress	27·9 tons.
Maximum twist per inch length	460°
Sclerescope hardness on case	80—90

* This represents more than five complete twists before breaking.

Machining tests at a surface speed of 130 ft. per min. on drawn bars, with a depth of cut $\frac{3}{16}$ in. and feed of 0·009 in. are claimed to have given excellent results, both for surface finish and screwing properties. Features of this alloy are its uniform free-cutting properties, glass-hard case, tough fibrous core, and excellent forging qualities. The other steel has been produced to stand up to the hardest wear and occasional misuse which occur in works. It is claimed to be about 20% stronger than the average 2. S.14 steel. This steel is designated C.H. 10, and an average sample taken on a standard $1\frac{1}{8}$ in. diameter piece, after double heat-treatment, gave the following result :—

Ultimate stress	40 tons per sq. in.
Yield	23 tons per sq. in.
Elongation	34% on 2 in.
Contraction	67%
Izod impact	Over 60 ft.-lb.
Sclerescope reading on the case	80/90


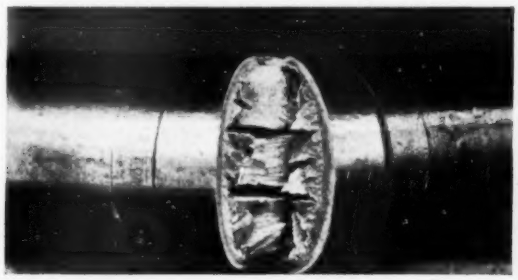

Fig. 1 and 2.—Nickel-Chrome Case-hardening Steel Fracture.

Fractures of a plain carbon case-hardening steel are illustrated in Figs. 1 and 2. This steel is produced by Swift, Levick and Sons, Ltd., who also manufacture a special nickel-chrome case-hardening steel which has a Brinell hardness of 159 to 167 in the rolled condition. After being carburised at 900° C. and allowed to cool, then reheated to 840° C. and quenched in oil, with a further heating to 750° C., and again quenched in oil, it is claimed to give the following results :—

Maximum stress	61 tons per sq. in.
Yield stress	44 tons per sq. in.
Minimum elongation	20% in 2 in.
Minimum reduction of area	52%
Izod impact	48·5 ft.-lb.

This steel is known as L.H.G., and is claimed to be particularly suitable for lorry change-speed gears, owing to the high core test it gives and its ability to withstand drastic gear changes.

Another nickel-chrome case-hardening steel of high quality was exhibited by Andrews Toledo, Ltd., and known under the brand B.C.H. An advantage claimed for this steel is that it does not present a definite demarcation between the core and the case. It is recommended that it should be carburised between 870° and 900° C., and allowed to cool out in a box, reheated to 850° C. and quenched in oil for refining, finally heating it to from 760° to 780° C. and quenching in water to harden. The following are typical physical properties of this steel, quenched in water at 760° C. :—

Tensile strength	50 tons per sq. in.
Yield point	41 tons per sq. in.
Elongation	25% in 2 in.
Reduction of area	50%
Brinell hardness number	228
Izod	80 ft.-lb.

Gear Steels.

Many special gear steels were exhibited, among which may be mentioned "Gearite" and "Gearol," of Swift, Levick and Sons, and Toledo "G 105." All are nickel-chrome steels, to conform with B.E.S.A. specifications. Gearite in its annealed state has a Brinell hardness of between 229 and 255, and after being hardened in air at a temperature of 830° to 875° C., is tempered in oil at 200° C. The physical properties of this steel are between the following figures :—

Maximum stress	105/118 tons per sq. in.
Yield stress	95/107 tons per sq. in.
Minimum elongation	12/10% in 2 in.
Minimum reduction of area	35/25%
Brinell hardness	444/555
Izod impact	25/18 ft.-lb.

"Gearol," in its annealed condition, has a Brinell hardness of 197 to 207, and is quenched in oil at 825° to 850° C., and subsequently tempered in oil at 200° C., which gives the following physical properties :—

Maximum stress	105/114 tons per sq. in.
Yield stress	102/107 tons per sq. in.
Minimum elongation	12·5/6·0% in 2 in.
Minimum reduction of area	38/8·5%
Brinell hardness	444/514
Izod impact	15/8 ft.-lb.

The "G 105" is also an oil-hardening steel, being heated to between 820° and 840° C., quenched in oil, and subsequently tempered at 200° to 230° C. A typical test-piece gives the following results when oil-hardened at 830° C. and tempered at 215° C. :—

Tensile strength	105 tons per sq. in.
Yield point	90 tons per sq. in.
Elongation	12% in 2 in.
Reduction of area	35%
Brinell hardness number	460
Izod	15 ft.-lb.

Tool Steels and Other Cutting Materials.

Important developments in the production of high-speed steels have taken place in consequence of the high cutting speeds and increasing resistance capacity of high-duty metals and alloys used in modern engineering. Many are of outstanding quality, and of these mention may be made of Hadfield's "Heclon Superlative." This steel is claimed to be unique, giving excellent results in the machining of manganese steel and in turning railway-tyre wheels, especially those that have been used and which have become glazed and hardened as a result of skidding and the burnishing action of brake blocks. This steel should be heated to a bright red (1100° C.) to forge and to ensure uniformity, and the heating should be done slowly. To harden, the cutting end should be preheated to a dull red, then heated quickly to a white heat (1,280° to 1,300° C.) and cooled at once in a strong blast of cold air. A longer soaking is necessary at this temperature than is customary with high-speed steels. Immediately after hardening, the point should be tempered at 580° to 600° C. A lead bath, with pyrometric control, is a suitable means of ensuring an adequate result. The lead should be maintained at a temperature of 590° ± 10° C.

Another high-efficiency steel of this character shown at the Exhibition was R.A.M. Toledo super-cutting steel. Two certificates were exhibited relating to tests carried out with this tool steel by the Sheffield Testing Works. One certificate indicated the manner in which this steel stands up to manganese steel. The other represented the comparative cutting efficiency, and showed an efficiency of 230% as compared with the Sheffield Testing Works' best standard steel. In hardening this steel a practical indication of the correct temperature is provided by the scale which forms on the tool between 1,250° and 1,300° C. The scale fuses and small bubbles are seen, and as these increase in size excessive heat is indicated. The tool should be cooled under strong air-blast, and, for a secondary hardening, cooled in still air after reheating slowly to between 550° and 600° C.

Associated with the high-speed steels, other cutting materials have an acknowledged value for the machining of all kinds of metals and alloys at high speeds, and also for use in positions subject to much friction. Of these materials Delero stellite has been considerably developed. It is an alloy of cobalt, chromium, and tungsten carbides,

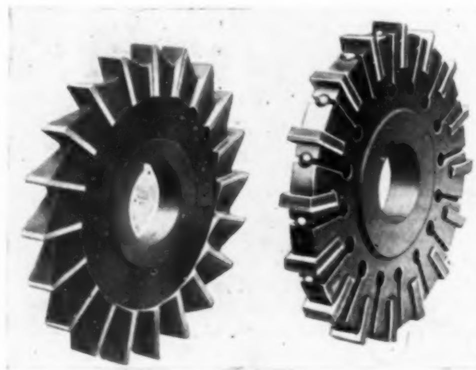

Fig. 3.—Stellite Milling Cutters.

melted in an electric furnace and cast into various shapes required. Tools produced from this material do not require hardening or tempering, and are claimed to produce more pieces per grind and to permit machining at higher speeds than high-speed or alloy tool steels. Milling cutters with inserted stellite blades, a tipped tool, and a lathe centre, having a stellite core, are illustrated in Figs. 3 and 4.

Heat-resisting Steels.

Among the many steels exhibited, the developments made in heat-resisting steels are facilitating their rapid progress in all branches of industrial practice. Their range of utility is constantly growing, and examples of a variety of work formed from Hadfield's "ERA HR" formed an interesting exhibit. These included a large high-pressure vessel, rotor and valve forgings, hot-drawn tubes, and a number of castings for furnace uses, conveyers, retorts, muffles, case-hardening boxes, hearth-plates, and others associated with the multiplicity of heating operations. A new development, demonstrated as heater elements in a

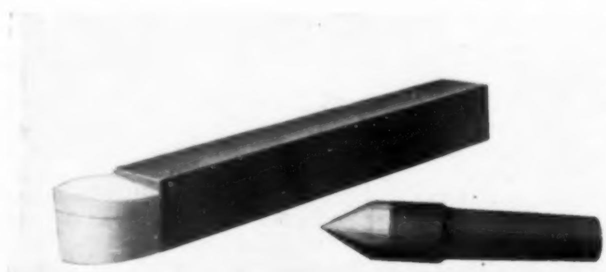

Fig. 4.—Stellite Tools.

furnace operating at 1,150°-1,200° C., is an alloy capable of resisting scaling up to 1,200° C. Its high electrical resistance is of the order of 140 microhms per cubic centimetre for the range 20°-200° C. Considerable attention is being given to the improvement of steels to meet the increasing high temperatures and pressures now coming into use in steam plant, particularly when the main problem is ability to sustain stresses at advanced temperatures without other special considerations, such as corrosion or

oxidation. Developments have resulted in the production of steels having two or three times the limiting creep stress at 540° C. of a 0·4% carbon steel.

Corrosion-resisting Irons and Steels.

The developments in stainless steel, which have made such remarkable progress, were well illustrated. The value of this alloy cannot be over-estimated because of the wide variety of its uses. In this connection the display of Firth "Staybrite" was very effective, as showing the extensive field open to these special steels. The chromium content of "Staybrite" is between 18 and 20%, nickel between 8 and 10%, and carbon below 0·2%. It is an Austenitic steel, which cannot be hardened or tempered, and when worked cold a tensile strength of 90 tons per sq. inch can be obtained. This steel has many applications where a non-corroding and acid-resisting metal is required, particularly in connection with the chemical trades.

What may be regarded as a super-stainless steel is the recent development of Monel-Weir, Ltd. Claimed to possess the advantages of stainless qualities with enhanced corrosion resistance and greater ease in fabrication, nickel-chromium-iron alloy is being marketed as a complementary to monel metal and pure nickel. This is another alloy, with relatively high percentages of chromium and nickel, and its strength is maintained at elevated temperatures—*e.g.*, the breaking stress at 400° C. is 30 tons per sq. inch, and there is practically no scaling at 900° to 950° C. Under normal conditions the phsyical characteristics of this alloy are as follows :—

	Hot Rolled Material as Rolled.	Softened by Water Quenching 1,000° C.	Hard Rolled or Drawn, M.W.
Maximum stress, tons per sq. in.	44	39	55
Yield point, tons per sq. in.	20	16	45
Elongation, %	50	70	30
Izod impact, ft.-lb.	112	107	—
Brinell	160	—	300

The EDROW brand of rust-resisting steel represents another exhibit which is resistant to atmospheric and other corroding conditions. It is supplied in sections, plates, and sheets, and produced by the Earl of Dudley's Round Oak Works, Ltd. As a result of tests, this steel has proved nearly eight times more rust-resisting than ordinary mild steel in a sulphurous atmosphere, and about twelve times more resistant in a hydrochloric atmosphere. Copper is so added that it in no way impairs its ductility and working properties. An analysis of this steel, together with the result of typical mechanical tests, is as follows :—

Carbon. %	Silicon. %	Sulphur. %	Phosphorus. %	Manganese. %	Copper. %
0·185	0·050	0·035	0·020	0·69	0·275

Elastic limit	16·2 tons per sq. in.
Maximum strain	29·2 tons per sq. in.
Elongation	26% on 8 in.
Contraction of area	55·2%

Some Other Alloy Steels.

Alloy steels of every description for aircraft, automobile work, locomotives, etc., were exhibited, including nickel, nickel-chrome, nickel-chrome-molybdenum, chrome, chrome-vanadium, silico-chrome, and silico-manganese steels, and no exhibit was more comprehensive in this respect than the United Steel Companies, Ltd., with its various constituent firms which form the group. Whether for high-speed steel for billets, bars, etc., forgings, drop-stampings, spring steel bars, etc., this firm manufacture alloy steels in all qualities, including stainless steels for all branches of the engineering industry.

Chrome-molybdenum is certainly one of the best, if not the best, highgrade steel for tubes, especially if exceptional strength is required after manipulation, such as bending, flattening, tapering, etc. For while it can be produced from the draw-bench with a tensile strength fully equal to a 0·5 carbon tube—*i.e.*, about 45 tons per square inch ultimate strength—in its fully softened condition, such as is utilised for manipulating, it is considerably softer than is obtained with a 0·35 carbon steel, consequently, in its fully softened condition, it can be more readily manipulated than a 0·35 carbon steel, and many operations can be performed with it which are altogether impossible with the 0·5 carbon steel. Yet after the manipulation has been performed, its 0·5 carbon tensile strength can be restored by the simple process of air hardening. Moreover, it is a very suitable material for hardening by quenching in oil or water. Up to 75 tons per square inch tensile (after being tempered back), it can be fully relied on. A selection of tubes formed from this alloy were exhibited by Accles and Pollock, Ltd. It may be added that chrome-molybdenum has a very high fatigue value, largely dependent, as with other steels, upon a correct final heat-treatment, and while chrome-molybdenum is a fine high-grade steel, a good knowledge of its reactions to heat-treatment is absolutely essential.

Of the many alloy steels exhibited, it is difficult to refrain from a brief reference to manganese steel, for which Hadfields are noted. It is used for such castings as dredger buckets, tumblers, links, bucket-pins, etc., for the wearing parts of stone-breaking and ore-crushing machinery, special railway and tramway track work, and for many other purposes when a material is required to withstand exceptional wear and abrasion. In a disc crusher manufactured by this firm, and exhibited, two discs of manganese steel revolve at a very high speed, one of which has a very rapid oscillating motion imparted to it. All parts against which stone comes into contact are of manganese steel, so that renewals are only required at long intervals.

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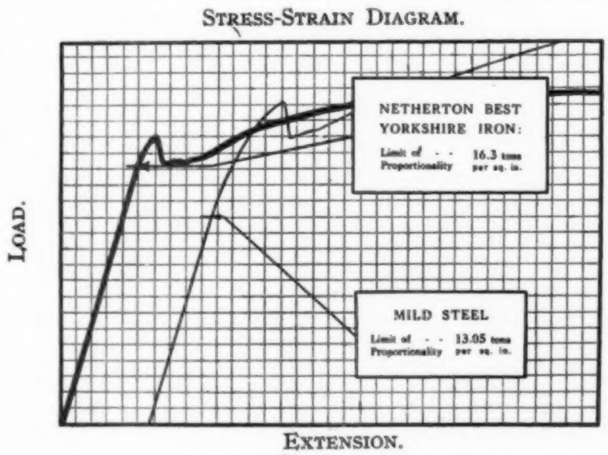
There was a considerable number of exhibits of wrought iron and mild steel. The threaded stay-bolts and miniature pump-rod forgings of Lowmoor iron, displayed by the Best Yorkshire Iron, Ltd., were full of interest. The resisting qualities of this iron were illustrated by an old boiler stay



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which had been in untreated water with 26° hardness for over 100 years, retaining 85% of its original section. The cold fibre and fracture tests illustrated the silky fibre and clean structure of the material. It is generally recognised that there is a revival in the demand for the best wrought iron, not so much to displace the cheaper qualities of steel, but for purposes where superior resistance to atmosphere corrosion is required, and when the strength to withstand sudden stress and unequal loads is essential. In the case of wrought iron and mild steel, there is a point at which the extensions cease to be proportional to the loads ; this is recognised as the limit of proportionality, and it is a fundamental factor upon which engineering structures depend. It is generally lower than the numerical value of the yield-point, but it is interesting to note that Netherton Yorkshire iron, manufactured by N. Hingley and Sons, with an ultimate strength of 21 tons per square inch, has a higher limit of proportionality than steel of an ultimate

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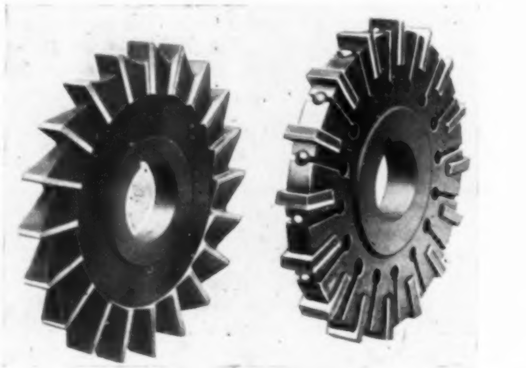

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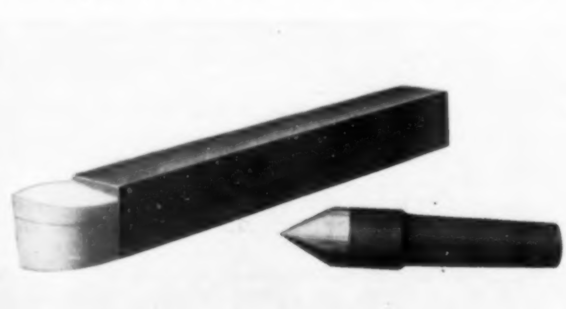

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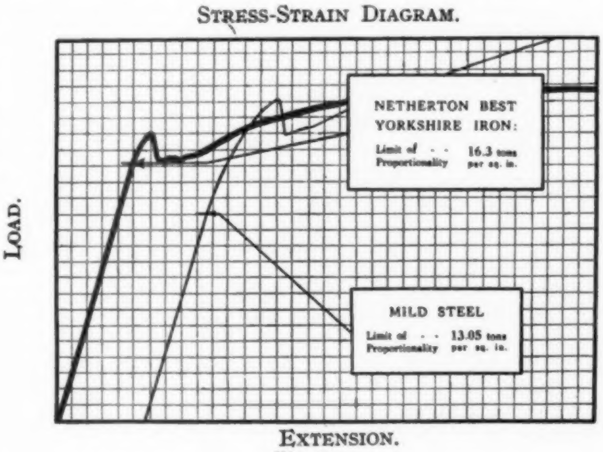
Stress-Strain Diagram.



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strength of 29 tons per square inch, although the yield-point of the steel may be higher, as shown in Fig. 5. Tested pieces of both iron and steel showing excellent quality were also exhibited by the Pearson and Knowles Coal and Iron Co., Ltd.

Forgings and Stampings.

The object of all forge-masters is to plan their forging processes in order to "work" adequately all parts of the ingot, bloom, or billet, from which the forging is made, so as to secure the proper flow of metal. The United Steel Companies claim to produce forgings so that this proper flow is secured, and are capable of dealing adequately with all forgings within certain weight limits. The combined experience of this company in dealing with various classes of this work is unique, and they include combination drop forgings, which are partly drop stamped and partly hand forged, and developments in this method have resulted in its increasing use economically. These combination forgings can be supplied in hardened and tempered alloy steels.

The forging exhibits of many firms were grouped in conjunction with the Drop Forgers' Association, and represented forgings in various types of steels conforming to British Standards. Many in this section made use of photographs to support exhibits, and notable of these was Messrs. Walter Somers, Ltd., who illustrated forged steel rings up to 9 ft. in diameter, a forged steel rotor-shaft for a 7,500 k.v.a. 3,000 r.p.m. 3-phase turbo-alternator, and a section of a large five-throw built-up crankshaft, among other interesting features. British Stampings, Ltd., had specimens of their steel drop-forgings from a few ounces to 3 cwt. each. This firm specialise in crankshafts, connecting rods, and fly-wheels, the work covering a range of work from 3 cwt. to 3 tons.

Semi-finished and Finished Material.

The wide variety of black and bright steel strip for tubes, motor rims and hubs, locks, hinges, pressings, blankings, etc., cut, nosed, splayed, and punched barrel hoops, exhibited by a number of important firms, indicates their extent of usefulness in industry. The same is true of bright steel bars and sections, the production of which has developed to such an extent that remarkable accuracy in dimensions is now possible, and these are available in a wide range of qualities depending upon the character of work for which they are required. Rope wire is a speciality of many firms, and was exhibited in various forms; some firms confine their production to acid steel because of the acknowledged greater service resulting in the use of steel manufactured by this process. But wire for a wide variety of purposes was on view, covering a range including ordinary bright and annealed wire, coppered, tinned, and galvanized mild steel drawn to finest limits; many registered brands of welding wire; spring, brush, mattress, reed, pin, flower, netting, half-round cotter, switching, rivet, boot, chain, buckle, and baling wire; pinion wire for meters, clocks, etc. Scaling wires and special sections applicable to many trades. A large range of weldless steel tubing of varying sections included examples of tube manipulation for flush pipes, exhaust pipes, golf club shafts, mantel rails, and window stands.

Non-ferrous Metals.

The developments illustrated in the non-ferrous field were considerable and notable among these exhibits was the recently developed P.M.G. metal of Vickers-Armstrong, Ltd. This is a high-grade copper alloy, possesses a short freezing range approximating between 950° C. and 900° C., and is consequently a good casting alloy. It can be readily forged, and in the wrought condition it possesses increased strength while retaining ample ductility. P.M.G. metal consists of 88% copper, 2% zinc, and 10% of the P.M.G. hardener. The special hardener has been developed to replace tin in gunmetal and other bronzes in the same percentages as it is usually introduced for particular mixtures. It is claimed that in Admiralty gunmetal a saving of not less than 17% is effected by the use of this hardener instead of tin.

A bar of P.M.G. metal, 3 in. diameter, forged to 1 in. diameter, gave the following mechanical test results :—

1. Finished forging temperature : Cherry red :—

Yield point	18·4 tons per sq. in.
U.T.S.	32·0 tons per sq. in.
Elongation	52% on 2 in.

2. Finished forging temperature : Full red :—

Yield point	25·2 tons per sq. in.
U.T.S.	34·8 tons per sq. in.
Elongation	32% on 2 in.

3. Finished forging temperature : Black :—

Yield point	36·0 tons per sq. in.
U.T.S.	42·0 tons per sq. in.
Elongation	17% on 2 in.

Density, forged, 8·44. Brinell hardness, 3,000 kgs. load, 10 mm. ball : Forged, 143 ; forged, finished cold, 149.

It will be seen from the above that an exceptionally wide range of mechanical specifications can be met by modifying the forging temperatures. The metal has also given evidence of superior anti-friction properties under high duty conditions, resistance to wet and dry sea-water corrosion and erosion as the result of tests, and it has demonstrated its suitability for super-heat and high-temperature service.

Monel Metal and Nickel.

The application of Monel metal to industry needs no introduction ; the developments associated with this metal involve the continually increasing uses due to its combination of toughness and strength, and its resistance to corrosion. Monel metal and nickel are being used for such widely different purposes as steam valves and hearth furniture, chemical plant and dairy equipment, shop fronts, and dyeing machinery. The exhibits of Monel-Weir, Ltd., illustrated the wide range of utility for power-plant purposes, a full-sized jigger lining and other examples associated with textile plant being shown, while a centrifugal basket of solid Monel metal for drying neutral ammonia was one of the many exhibits connected with chemical plant.

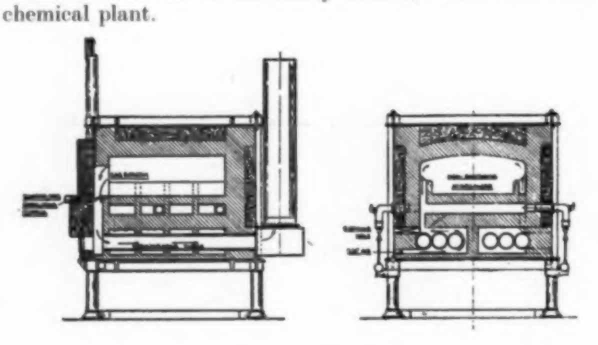

Fig. 6.—Lucas Patent Anti-scale Economiser Furnace.

A recently developed alloy, known as NIMOL, and produced by Monel-Weir, Ltd., contains about 20% of Monel metal, and is referred to as a cast-iron alloy. It possesses pronounced resistance to heat oxidation up to 600° C., and is claimed to be free from the destructive growth which characterises normal cast iron. It is essentially a cast material. The tensile strength of this alloy is between 9 and 12 tons, and fracture occurs with appreciable elongation. It possesses the easy machinability characteristic of grey cast iron. A valuable quality is its resistance to insidious destruction by rust, and comparative tests have shown that it possesses improved resistance to both sulphuric and hydrochloric acids.

On the stand of the Bureau of Information on Nickel of the Mond Nickel Co., Ltd., were displayed representative exhibits of the most important nickel alloys, while a series of wall decorations, illustrating the different branches of engineering—*i.e.*, automobile, civil electrical, marine, etc., the chemical and mining industries, and modern architecture—drew attention to the extensive and ever-increasing part played by nickel and its alloys in modern industrial developments.

One of the most important groups of alloys is that of nickel with copper. The resistance to corrosion of such

alloys renders them eminently suitable for turbine blading, valve parts, pump rods and impellers, pickling plant, and for decorative fittings. One of the most interesting applications, however, is that of condenser tubes, and a set of such tubes was exhibited ranging in composition from pure nickel to pure copper. Alloys containing 30% of nickel and upwards are widely used at the present time for merchant ships and also by the British Navy.

A section of a petrol-pressure casting, illustrated the rapidly expanding growth in the use of nickel cast iron. The development of nickel cast iron, containing up to 5% nickel, is comparatively recent, but within the last few years it has been gaining favour for such purposes as cylinder blocks, pressure castings, and for castings having thick and thin sections, which are difficult to cast satisfactorily in ordinary iron. The improvements obtained are due to the refining action of the nickel, which, when added to a suitable base iron, produces a sound dense casting, free from porosity and hard spots.

The non-ferrous alloys were represented by pure nickel tubes in various sizes, a nickel-chromium carburising box and electric heater, with nickel-chromium elements, a Jaguar aero-engine piston in "Y" alloy, and a plumbing fitting in nickel silver. A Monel metal pump impeller and a lift panel in Silveroid illustrated other applications of nickel-copper alloys.

Copper and Bronze.

In some instances rolled copper, phosphor bronze, aluminium bronze, gilding metal and brass were so arranged that the observer could readily see not only the outer surface but also a large proportion of the inner surface of coils displayed. This arrangement revealed a brightness and finish of surface free from defects such as spilliness and discoloured patches, usually associated with metals of

Fig. 7. Magnet Standard Furnace.

inferior manufacture. Makers of stamped, drawn, or spun-metal goods will appreciate the great saving effected by using material of this character, as great loss is frequently incurred at each operation, due to the waste involved where the metal is not up to standard, and when the articles have finally to be polished and plated the direct saving in polishing costs alone has often amounted to more than 2d. per pound, as compared with the use of inferior metal.

Much confusion has arisen from time to time in the metal trade owing to the want of uniformity in the tempers requisite. J. F. Ratcliff (Metals), Ltd., have standardised a range of eight different finishes which they believe include all the necessary degrees of hardness and working properties likely to be required. These finishes are arranged in the order of their Erichsen value as follows :—(1) Soft ; (2) non-porous ; (3) half-annealed ; (4) quarter-hard ; (5) half-hard ; (6) three-quarter hard ; (7) hard ; (8) very hard.

(1) Soft metal is suitable for deep stamping, drawing, spinning, etc.

(2) Non-porous metal, whilst not capable of drawing quite so deep as the soft, has a smooth surface when drawn or stamped, due to the small grain size, and does not present that "orange-peel" surface so frequently to be seen in over-annealed and metal of inferior mixture.

(3) Half-annealed metal is used when a certain hardness and brightness is required after it has been stamped. This finish is very useful when a shallow article has to be produced in one operation, and there is no necessity for further annealing.

(4) Quarter-hard metal may be used for very shallow pressings, and is capable of being folded flat both ways of the grain—that is, to an angle of 180°—without fracture.

(5) Half-hard metal will bend at an angle of 180° across the grain and at right-angles along the grain. It is also used for springs which have to be rolled, curled, or bent.

(6), (7), and (8) Three-quarter hard, hard, and very hard tempers respectively, are used for flat work or springs. The angle at which these are capable of being bent will depend upon the degree of hardness required.

A comprehensive range of non-ferrous manufactures was illustrated by Earle, Bourne and Co., Ltd., including cold-rolled brass of various compositions and copper ; solid-drawn brass and copper tubes for locomotives, condensers, sugar refineries, and general engineering ; brazed brass and copper tubes of a wide range of sections, together with exhibits of copper bends for sanitary, plumbing, and heating trades.

The exhibition illustrated considerable progress in the wider application of brass and bronze die-pressings, and many interesting exhibits were presented. Mention may be made of Brookes and Adams, Ltd., who have been long established, and consequently have wide experience of this class of work. The alloys upon which they concentrate for die-pressing are brass and manganese bronze, and their special alloys have the following physical properties :—

	Brass.	Bronze.
Ultimate strength, tons per sq. in.	24	32
Yield, tons per sq. in.	12	15
Elongation, %	30	30

Owing to the smooth and clean surfaces produced on die-pressings, machining, when necessary, is easily and quickly done, and in many instances results in much saving ; further pressings can be produced within very fine limits.

Castings.

It will be readily understood that any metals having different electrical potentials must necessarily lead to electro-chemical action and selective corrosion. Stainless steel castings are Austenitic, and in consequence have like electrical potentials, hence selective corrosion and electro-chemical erosion are at once dispelled. Extraordinarlyy high tensile and yield points are obtainable, together with high elongation. Recent tests on a stainless steel produced by Martin Industries, Ltd., gave the following results :—

Ultimate breaking strain	54 tons per sq. in.
Yield point	32 tons per sq. in.
Elongation	44%
Reduction in area	53%
Brinnell	175

whilst recent chemical tests have shown the following analysis :—

Carbon. %	Manganese. %	Nickel. %	Silicon. %	Chromium. %
0·14	0·28	8·3	0·04	18·8

Hydraulic tests have shown that a casting will withstand exceptionally high pressures. A comparative test was undertaken in which a casting resisted a pressure of 1,000 lb. per square inch without any defects, in stainless steel, whereas a similar casting in brass burst under a pressure of 400 lb. per square inch. The use of manganese steel has

already been referred to, but considerable progress is being made in the production of castings in a wide variety of alloy steels.

Probably no great developments in regard to castings have taken place during recent times comparable with those in the production of malleable iron castings. It has been customary in this country and on the Continent to produce the Reaumur or whiteheart variety, but as a result of considerable research it has been found that the manufacture of blackheart castings can be conducted on a competitive basis providing the selection of materials, melting, and heat-treatment are scientifically arranged and controlled. Of these two distinct variations in the manufacture of malleable iron castings, the Reaumur method, by which whiteheart castings are produced, is the original one; the American or blackheart method being a later development. In whiteheart castings the carbon in the original casting is not only separated from the combined state, but a proportion of it is completely removed from the metal. In the blackheart method the object is simply to separate the carbon into the free state. This is claimed to give the casting superior physical properties combined with machinability and reliability. Physical tests relating to Ley's blackheart malleable iron gave the following particulars :—

On round bar, 0·66 in. diameter :—

Yield point	15 to 17 tons per sq. in.
Ultimate tensile strength ..	22 to 26 tons per sq. in. *Average 23·7 tons per sq. in.
Elongation	10 to 18% in 3 in. *Average, 14.5%

* These averages are taken from tests made on every heat over a long period.

On bar 1 in. × ¾ in.—

Cold bend round 1 in. dia...	170° to 180° without fracture.

On notched bar, 10 mm. × 10 mm.—

Impact test	8 to 11 ft.-lb.

The blackheart process, as distinct from the whiteheart process, does not rely on oxidising packing for softening

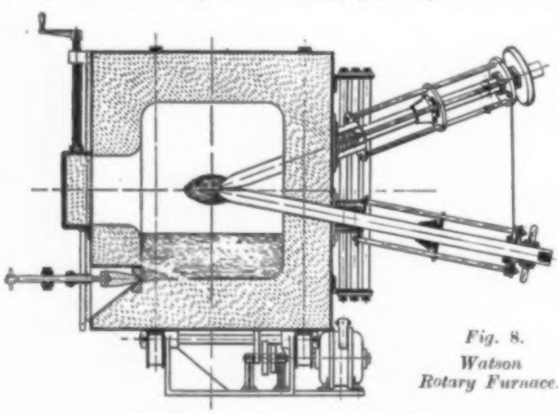

Fig. 8. Watson Rotary Furnace.

purposes. The object of the heat-treatment is to break down the iron carbide, which makes the casting hard and brittle, into its constituents in an exceedingly fine division. Chemical composition plays an important part in the heat-treatment, consequently there is need for strict control of the metal. Of the outstanding exhibits representing this speciality work, those of Thomas L. Hale, Ltd., and Ley's Malleable Castings Co., Ltd., indicated the increasing scope of malleable castings for a wide range of purposes. The Coventry Malleable and Aluminium, Ltd., also exhibited some interesting malleable iron castings. The castings in aluminium shown by this firm were also worthy of note. The developments in the production of corrosion-resisting aluminium alloys are very important, as there is no doubt that aluminium alloys capable of resisting corrosive influences and yet possessing good physical qualities constitute a great advance in aluminium metallurgy. The basic principle of metals that resist corrosion concerns the formation of a protective film, usually an oxide, in order to prevent or delay further attack. The nature of the film formed is of great importance, and aluminium alloys may be classified in three groups according to their behaviour: Those that are easily corroded protective film formers, resistant film formers, and non-corrosive film formers. It is this latter group from which developments indicate that alloys of really good resistance to corrosion are possible, and in addition these alloys maintain good physical properties.

Where large quantities of aluminium castings are required the advantages associated with the production of die-castings cannot reasonably be overlooked. Castings that are homogeneous, uniform in size and character, accurate, and made to fine limits, are being consistently produced by a number of progressive firms by both the pressure and gravity processes. Die-castings having these special advantages are not only being produced in aluminium alloys, but in a variety of alloys, and while pressure die-casting is at present limited to low temperature metals and alloys, developments of the process in progress have facilitated its application to brass, and soon gunmetal, aluminium bronze, and probably copper will be used by this process.

Heat-treatment Furnaces.

A feature of the Exhibition was the number of furnaces on view in a working condition, particularly those specially designed for heat-treatment. One of these, a Lucas patent furnace, was gas fired on natural draught, suitable for temperatures up to 1,050° C., fitted with metal recuperator for utilising the waste heat to pre-heat the secondary air necessary for intensifying combustion, and a gas screen at the front to prevent the air entering the chamber when the door was open. Internal dimensions of the working chamber were 12 in. wide × 18 in. deep × 9 in. high to crown of arch. Specially insulated and built-in patent tubular casing with lifting counterbalanced door, was an interesting feature of this furnace. It was fitted with a Cambridge pyrometer. A similar furnace was also arranged for oil firing, but was not operating. A sectional elevation and cross-section of this type of furnace are shown in Fig. 6, from which it will be noted that products of combustion enter on both sides of the heating chamber and then pass forward through its full length, when the waste gases pass over the front edge to the recuperators. This creates a gas screen at the front of the chamber, controlled by a damper sill, which enables operations to be carried out under the necessary open-door conditions without affecting the atmosphere and even heat of the chamber. The recuperator chambers are continuous throughout the full length of the furnace, and are of metal, owing to its increased thermal conductivity over firebrick. The waste gases enter the recuperators at practically the same temperature as that of the furnace. The secondary air enters at the sides of the furnace walls through regulated ports immediately below each burner, and is induced around the recuperators before meeting the fuel gases. The waste heat is thus efficiently utilised for heating the secondary air for supporting and intensifying combustion, the air being heated to practically the combustion point of carbon, which gives a spontaneous mixing and prevents free oxygen from coming in contact with the work. On leaving the recuperators the waste gases pass into a main flue of sufficient height to pull them into the recuperators at the front downtake, which is provided with a damper for regulation according to the working temperature of the furnace. A balance of pressure is maintained when temperature is obtained.

These furnaces are claimed to maintain an even temperature throughout the chamber, and in consequence of efficient recuperation and insulation considerable economy is effected.

Another interesting type of furnace suitable for annealing, hardening, tempering, case-hardening, and normalising steel, and for annealing, normalising and heat-treatment of brass, copper, aluminium, and other non-ferrous alloys was illustrated by the Magnet electric furnace. A standard

muffle furnace, shown in Fig. 7, is of 8 k.w. capacity, suitable for a maximum working temperature of 1,000° C. The muffle in this type is of refractory fireclay wound with highest grade nickel chromium wire, and so arranged as to give an even temperature throughout the length of the muffle. The terminal box is at the back of the furnace, and the pyrometer flange and hole is also fitted at the back. The automatic temperature control panel is shown mounted alongside the furnace. A Magnet annealing electric furnace having a chamber 66 in. long, 35 in. wide, and 20 in. high was exhibited. The heating elements incorporated in this furnace are arranged along the sides and under the hearth-plate, and consist of large-diameter nickel-chromium wire. An interesting feature about this furnace is the hand-operated mechanism which controls the door.

The G.E.C. also showed a sectional model of the Grunewald electric bright-annealing plant, for steel and copper strip and wire in coils: samples which have been bright annealed were displayed. The remarkable efficiency of the Grunewald process, for which the G.E.C. have the sole manufacturing and selling rights for the British Empire, made this exhibit one of the outstanding features at the Fair.

Another electric furnace designed more particularly for hardening was that exhibited by Wild-Barfield. The arc is made in twelve vertical types as well as a horizontal type, while the special feature about these electric furnaces is the magnetic indicator, which operates automatically irrespective of the size, shape, or analysis of the steel. This indicator, fitted to the heating chamber, indicates by the loss of magnetism in the charge, and enables the operator to quench at the right moment. The most difficult sections to be hardened can be accomplished in this manner with scientific accuracy.

A rotary furnace for heat-treatment is somewhat unusual, and such a furnace was exhibited by R. M. Catterson-Smith. It possessed a hearth in the form of a rim, 4 in. wide with a mean length of 7 ft., constantly rotating. Articles to be heat-treated slide on to the hearth from a hopper fitted in the top of the furnace. They are carried under a pre-heater panel of nickel chrome, from which they pass into the final heating zone, heated by silit resister rods placed in refractory carriers above the hearth. The hearth is formed of sillimanite refractory, and is carried on an insulating ring of special section, on which it is located by flanges, the lower ring being elongated downwards and deeply slotted underneath. It is mounted on a heat-resisting metal ring which rests on three rotating supports. The hearth is driven by a $\frac{1}{8}$-h.p. motor and a heliocentric reduction gear. It can be arranged for any speed of rotation: as shown it was making one rotation in three minutes. In heating up, the furnace consumes 5 to 6 k.w., and to maintain the temperature at 900° C. requires 3·5 k.w.

An ingenious twin-tube furnace was exhibited for automatically delivering brass billets for hot-press work. It handles round billets, $\frac{5}{8}$ in. diameter up to 2 in. long, with an output of eight per minute at a temperature of 800° C. The billets are placed in hoppers, from the bottom of which they are pushed, one at a time, at regular intervals alternately, into twin staybrite steel removable liners, each billet pushing forward those already in the liner. The liners are contained in nickel-chrome wound heater tubes, 20 in. long, and a final heating chamber, 7 in. long, heated by silit rods. The billets are progressively heated as they pass through the liner and are ejected at about 800° C., sliding down channels to a convenient position for seizing by tongs. A constant temperature at the delivery end is maintained by an automatic control actuating a clapper switch in the main circuit.

The feed mechanism consists of rods mounted between rollers in line with the furnace tubes and actuated by solenoids located below the furnace. The rate of feed is timed by mercury switches in the solenoid circuits mounted on a camshaft rotated by a small motor and reduction gear. The speed of rotation can be altered by a sliding resistance in the motor circuit. The furnace is an independent unit which can readily be disconnected and removed. A hinged lid carrying the top heat insulation allows for removal and replacement of the nickel-chrome heater tubes. The efficiency of this furnace is high, about 70% of the total input being absorbed in heating the billets, and the maximum consumption is 3·2 k.w.

Melting Furnaces.

Considerable developments have been made during recent years in the use of electricity for melting ferrous and non-ferrous metals and alloys. Formerly this was looked upon as an extravagant melting unit, but the high efficiency obtained in modern furnaces is now recognised and due allowance made when comparing costs. The advantages associated with the use of electric furnaces are very considerable and command the attention of all interested in melting high-quality metals. Clean melting, uniformity of heat imparted, and accuracy of control are important factors favourable to the use of electricity, and the ease of operation, together with the absence of combustion gases, cannot be overlooked. Electric furnaces offer considerable advantages in the melting of non-ferrous alloys, as, for instance, it is not necessary to eliminate the effect of combustion gases, since there are none likely to influence the charge. Arc furnaces of the rocking and rotary type have been developed in order to distribute the heat in the charge and reduce to a minimum losses due to volatilisation. An outstanding factor of considerable importance is the thorough mixing to which the metal is subjected. A furnace of this type exhibited was the "Watson" electric rotating furnace, which has been specially designed for the manufacture of brass and copper alloys. This furnace, which is illustrated in Fig. 8, consists of a stout steel barrel lined with suitable refractory materials and supported on rollers. Suitable switch-gear provides for rotation in either direction, giving control of the spout for pouring purposes.

The heat in melting in the "Watson" furnace is obtained by means of an arc formed between two or more electrodes, which is magnetically blown into a large flame, giving an even distribution of heat to the interior of the furnace. When a good bath of metal is formed, the furnace is slowly rotated, the metal taking up excess of heat from the lining. The furnace maintains a reducing atmosphere, and, in consequence, the use of dioxidisers is unnecessary. This furnace is designed and built as a result of experience gained in the design and operation of electric furnaces for steel production represented by the Greaves-Etchells electric furnaces, which have many interesting features.

A small Ajax-Northrup high-frequency furnace was exhibited by the Electric Furnace Co., Ltd. This unit is suitable for use in laboratories, and also illustrates the

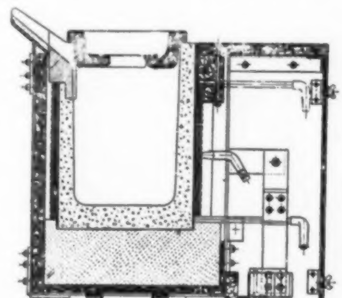

Fig. 9.—Ajax-Northrup High-frequency Furnace.

principle to such an extent that furnaces of a capacity of one ton of steel per hour are in operation and furnaces up to five tons capacity have been designed. A sectional illustration of this furnace is shown in Fig. 9. A new type of poking machine was also shown which is used for stirring brass swarf in Ajax-Wyatt furnaces. This machine is claimed to reduce labour costs, power consumption, and increase the number of heats produced in a given time by over 20%. The types of furnace which they construct, as

with other makers, are generally of far too large a size for them to be shown in operation at an exhibition, and consequently their principal furnaces are shown by means of photographs of installations, drawings, etc.

The Electric Resistance Furnace Co., Ltd., normally supplies plant too large to be shown at an exhibition, but they had an interesting exhibit of a melting pot heated by electric resisters, for aluminium, lead, and other metals of low melting point. The pot shown had a capacity of about 200 lb. of aluminium, but they can, however, be made in sizes varying from 20-lb. up to 5 tons.

Melting equipment for the iron foundry was represented by the bottom section of a cupola exhibited by Alldays and Onions, Ltd. The cupola is undoubtedly the most economical melting unit for the iron foundry, and with proper charges and reasonable care in its manipulation good quality metal can be produced.

Welding and Cutting Appliances.

In recent years, welding has more and more come to be considered not merely as mainly a useful repairing process, but as a valuable production process also, and many of these outfits have been bought for regular production work. This increased use of welding has in many cases resulted in changes in design, since it is upon this factor of design that the efficient use of welding largely depends. An interesting aspect of welding progress is the frequent substitution of arc-welded steel structures for iron castings. Considerable savings have been effected in this way, particularly where relatively few castings are to be taken from the same pattern, and where, consequently, the cost per casting is considerable.

A full range of welding equipment, including oxy-acetylene, electric arc, and electric resistance, were shown by Messrs. Allen-Liversidge, Ltd. These three processes between them cover almost the entire welding field, from individual repair jobs to mass production of thousands of welds per hour with a resistance welder. The oxy-acetylene equipment shown includes high-pressure welding outfits which employ dissolved acetylene in cylinders, as well as the compressed oxygen; and low-pressure plant for which the acetylene supply is drawn from a generator.

A resistance welding machine exhibited by this firm and employed mainly for repetition work was the "Pontelec," which is illustrated in Fig. 10. Manufactured by Buckley Saunders and Co., Ltd., it is specially adapted to light sections of metal, and remarkable results have been obtained in both spot and seam welding. The following particulars relative to spot-welding clean mild-steel plate may be of interest :—

Single Metal Thickness.	Total Aggregate Thickness Inches.	Welds per Unit, Approx.	Time of Each Weld in Seconds.	Diameter of Spot Inches.	Approx. Cost of 100 Welds at 1d. per Unit.
34 S.W.G.	0·0184	4,800	0·25	$\frac{1}{16}$	$\frac{1}{48}$ of 1d.
28 ,,	0·0296	3,400	0·3	$\frac{1}{16}$	$\frac{1}{34}$,,
26 ,,	0·036	1,800	0·5	$\frac{1}{8}$	$\frac{1}{8}$,,
24 ,,	0·044	1,450	0·5	$\frac{1}{8}$	$\frac{2}{29}$,,
22 ,,	0·056	1,200	0·6	$\frac{1}{8}$	$\frac{1}{12}$,,
20 ,,	0·072	1,000	0·6	$\frac{1}{8}$	$\frac{1}{10}$,,
18 ,,	0·096	850	0·7	$\frac{1}{8}$	$\frac{2}{17}$,,
16 ,,	0·128	750	0·8	$\frac{3}{16}$	$\frac{2}{15}$,,
14 ,,	0·160	515	1·0	$\frac{3}{16}$	$\frac{20}{103}$,,
12 ,,	0·208	360	1·25	$\frac{3}{16}$	$\frac{5}{18}$,,
10 ,,	0·256	240	1·5	$\frac{3}{16}$	$\frac{5}{12}$,,

A range of welding transformers with choke-coil regulators was shown by the Premier Electric Welding Co., the two principal examples being a 200-amp. transformer of the air-cooled type, and a small 75-amp. transformer specially designed for welding thin sheet metal. As this latter transformer has an open circuit voltage of only 40 volts on the secondary side, its energy consumption is almost negligible, and it can be placed, without difficulty, in any ordinary A.C. single-phase lighting circuit. It should appeal very strongly to manufacturers of thin sheet-metal equipment, and garage proprietors, especially, as the first cost is extremely low.

A new process of considerable interest was the "Premag" process for welding copper. This process, which has been worked out in conjunction with I.C.I. metals, is an oxy-acetylene process for welding copper, and gives astonishingly good results. The process was demonstrated, and a number of commercial copper vessels constructed by its use were exhibited, as well as test-pieces and sample welds.

Three types of arc welding plant were exhibited by G. D. Peters and Co., Ltd. All were fitted with "Wilson" K-5 type automatic current-control panel, by means of which the current can be regulated so as to be steady and uniform, the variation not being greater than 5%. This has the effect of maintaining the heat in the weld both local and constant, and, in addition to all usual welds in steel, it enables the welding of large iron castings to be undertaken without pre-heating. This is claimed to be a great advantage, since heavy machines can be repaired without the need of dismantling. Fig. 11 illustrates a two-operator stationary set. The scope and potentialities of the oxygen cutting and welding process were shown by the British Oxygen Co., Ltd., who demonstrated a 55 in. Universal

Fig. 10.—An 18 k.v.a. Pontelec Electric Spot Welder.

cutting machine on actual cutting jobs. This machine is capable of producing any required shape from steel plate up to 15 in. thick, and its use eliminates many of the disadvantages of forged and cast parts.

Refractories.

Of the many refractory materials inseparable from furnace construction, some interesting features were shown by General Refractories, Ltd. Their "Insulite" insulating bricks, a layer being shown in a kiln wall, attracted attention. A special high-temperature cement, known as "Pyrolyte," was also on view, and, in addition, a wide range of British sands for all classes of foundry work, firebricks, magnesite bricks, and all types of refractory bricks for furnaces, etc. In connection with firebricks, it has long been known that an increased percentage of grog (pre-calcined material) increases the resistance of the brick both to chemical attack and to thermal shock, and in the new products of Timmis and Co., Ltd., this is carried to its logical conclusion—viz., the manufacture of a brick

from grog alone. In the course of their investigation on both a small and a large scale, it has been necessary completely to revise the methods normally adopted in firebrick making. It is claimed that the differences between grog bricks and ordinary firebricks are just as wide as the differences between an ordinary firebrick and a silica brick.

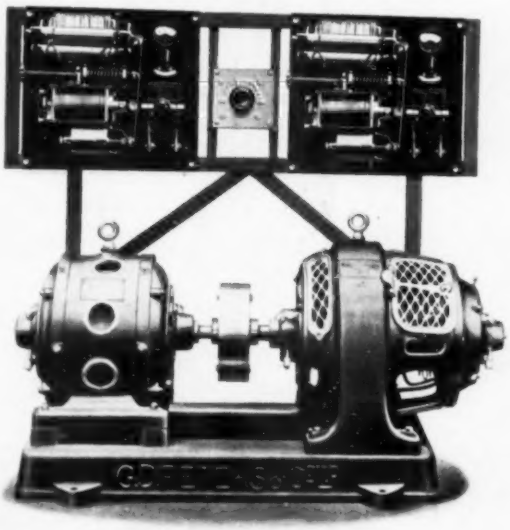

Fig. 11.

Silica bricks were displayed by the Meltham Silica Brick Co., who specialise in this type of brick. Their exhibit consisted principally of a built-up silica coke-oven wall, built-in sections of vertical and horizontal segmental gas retorts, and a general display of various shapes and sizes for the heavy industries. In addition, many samples of super-refractories, such as magnesite, chrome, and silimanite bricks and blocks were displayed.

Electrical Equipment.

Modern ideas and methods in the use of electrical equipment, to secure greater efficiency and increased production, were illustrated by many firms. Many exhibits were at work so that visitors could see their method of operation, this applying particularly to motors and control gear for industrial service, comprising, in the principal, standard forms for A.C. and D.C. circuits, the sizes on view including fractional horse-power and larger ratings, as well as the newer " built-in " motors, and worm-geared motor units. The machine-tool industry has derived many benefits as a result of electrical power, and one of the most recent and important is the introduction of " built-in " motors for giving direct drive to machine tools and wood-working machinery. In this connection the B.T.H. " built-in " stator and rotor units were of great interest to machine-tool manufacturers. These are complete as regards the essential electrical and magnetic portions of a three-phase A.C. motor. The stator unit consists of a core and winding in an enclosing shell, and the rotor unit a squirrel-cage rotor with centrifugally cast aluminium bars and end rings.

The units are assembled by the machine-tool makers and housed in frames which are designed as integral parts of the machine tools, and the machine-tool makers also provide shaft, end-shields, and bearings as part of their design. The equipment on a lathe is illustrated in Fig. 12. It is an overhung end-shield mounted D.C. motor, bolted up to the base of the machine. A small auxiliary motor, similarly mounted, is also provided for traversing the saddle. Vertical spindle motors and hand-operated control gear are shown in Fig. 13, fitted to a drilling machine.

Many equipments for the control of A.C. and D.C. reversing and non-reversing motors of various sizes were shown, in forms for either wall or floor mounting. Amongst these was an improved oil-immersed A.C. motor-control panel, type A.T.M. form T, designed for starting and protecting three-phase non-reversing slip-ring induction motors up to 15/20 h.p., at any voltage up to 550, at 25 and 40/50 cycles, maximum stator current 30 amperes, including the standard B.E.S.A. overloads and rotor current, not exceeding 75 amperes.

Pyrometry.

In addition to a representative collection of instruments for engineering and industrial purposes, including electrical CO_2 indicators and recorders, apparatus for recording the percentage of dissolved oxygen for boiler-feed water, draught and pressure gauges, there were many temperature measuring instruments, and other instruments for engineering and electrical measurements. Of these mention may be made of the Féry radiation pyrometer, exhibited by Cambridge Instrument Co., which depends for its operation upon the heat radiated from the hot body. It is suitable for measuring temperatures of hot furnaces, rolling mills, brick kilns, pottery kilns, glass furnaces, pouring temperatures of molten metals, etc. A portable outfit was exhibited comprising a telescope (which is sighted upon the hot body) mounted upon a tripod stand, and connected by a short length of leads to a portable indicator, from which the temperature is read. The standard range for portable outfits are 500°—1,100° C., 600°—1,400° C., and 800°—1,700° C. Permanent indicating, recording or combined indicating and recording outfits for one or a number of points can be supplied, the standard ranges for these outfits being 600°—1,200° C., 700°—1,400° C., and 900°—1,700° C.

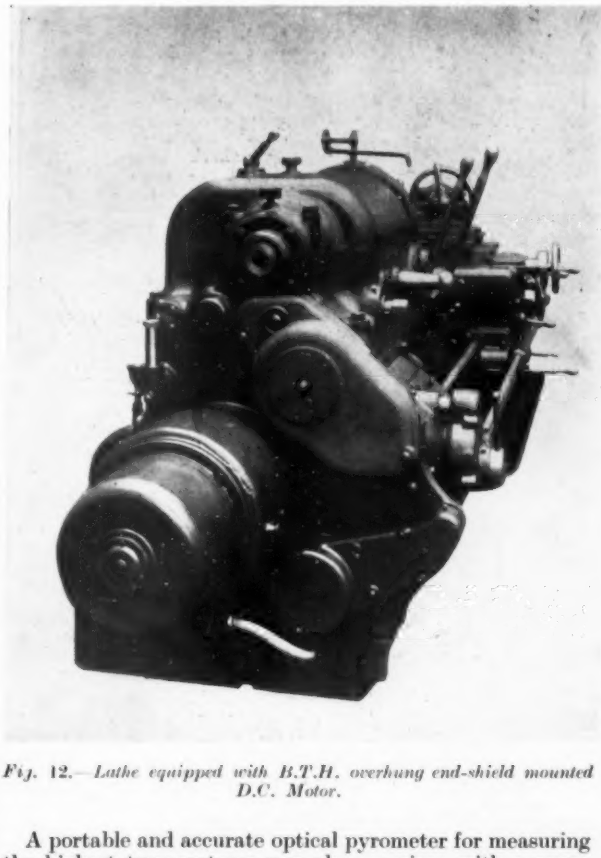

Fig. 12.—Lathe equipped with B.T.H. overhung end-shield mounted D.C. Motor.

A portable and accurate optical pyrometer for measuring the highest temperatures was also on view, with a range of measurement from 700° C. to 4,000 C. This instrument may be regarded as a photometer, in which by simply rotating the eyepiece a beam of mono-chromatic light from the hot body is adjusted to be of the same intensity as a beam of light from a standard incandescent lamp;

attached to the eye-piece is a pointer which indicates the temperature directly upon a clearly divided scale.

An interesting optical precision pyrometer was exhibited by Viozone, Ltd., known as Pyroversum II. This instrument consists of a calibrated metal frame with a shaded glass in the centre, graduated from reddish opaque to a dense opaque. A worm spindle for fine adjustment extended from end to end at the back of the frame, and operated by a thumb-screw, ensures accurate and steady readings of all temperatures. This is a new improvement, which covers accurate readings from 900° to 2,000° C. A disappearing filament pyrometer, also exhibited, is a simple, portable instrument for use where the high accuracy of the Cambridge optical pyrometer is not required. It is capable of measuring temperatures up to 2,100° C. The instrument comprises an electric lamp, a small ammeter, and a rheostat. The current through the lamp is adjusted until the top of the filament is of the same brightness as the hot body, and disappears when viewed against it. The temperature is then read on the ammeter scale.

Pulverised Fuel.

A striking feature of the exhibition consisted of a No. 6 Atritor Unit Pulveriser (which has a capacity of 500 lb. of coal pulverised per hour) at work firing a forging furnace. Raw coal, sufficient for about eight hours' run, is stored in an overhead bunker and falls by gravity into the hopper of the machine. The rate of feed to the Atritor, and consequently to the furnace, is controlled by a small handle on the Atritor body. The machine takes the raw coal and automatically separates out all metal and stone. The coal

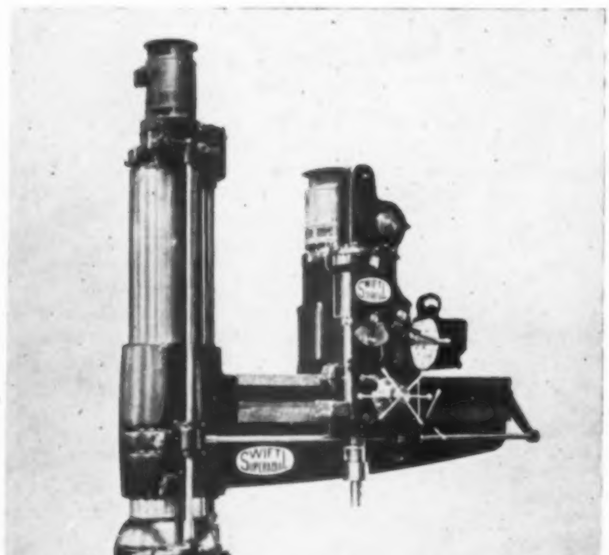

Fig. 13.—Drilling machine fitted with B.T.H. vertical spindle motor.

is then dried, pulverised, and finally blown to the burner mounted in the furnace arch. The whole process is automatic, and the machine can be left unattended for lengthy periods. Drying is done by hot gases drawn from the furnace. The furnace was of the standard type, exhibited by Alfred Herbert, Ltd., and served to illustrate the ease with which pulverised fuel can be applied to the firing of metallurgical furnaces.

Considerable progress has been made in the application of pulverised fuel to metallurgical furnaces during recent years. The better design of both burners and machinery entering into pulverised fuel systems have made possible heat liberation at high rates and G.P.F., Ltd., have a range of burner and control equipment suitable for all types of furnaces using pulverised fuel. It has been found necessary to develop a variety of burners for metallurgical purposes to suit the varying operating conditions of different furnaces, the class of product dealt with, and the required combustion temperatures.

ANNUAL MEETING OF MECHANICAL ENGINEERS.

The annual general meeting of the Institution of Mechanical Engineers was held on February 21, at Storey's-gate, Westminster. The chair was occupied during the early part of the proceedings by the retiring president, Dr. Daniel Adamson, who, after the ordinary formal business had been despatched, awarded the prizes which had been gained during the past year. These prizes were awarded as follows :—A Thomas Hawksley Premium to Mr. R. W. Bailey ; Thomas Lowe Gray Prizes to the late Professor H. L. Callendar (handed to his son), and to Dr. Hubert Mawson ; Herbert Akroyd Stuart Prizes to Professor E. A. Allcut and to Mr. A. L. Bird ; a T. Bernard Hall Prize to Mr. F. C. Johansen ; and George Stephenson Research Prizes to Mr. T. M. Herbert and Mr. C. F. Dendy Marshall. The thanks of the Institution were extended to Mr. William Reavell and Mr. H. L. Guy, whose papers, as presented by Members of Council, were not eligible for award. Students' Examination Prizes were awarded to Mr. W. P. F. Jolly and Mr. R. T. Insley, and an Associate Members' Examination Prize to Mr. Iqbal Singh.

Subsequently the President proposed the adoption of the annual report, and commented on the fact that out of the eighteen papers presented, fifteen were contributed by members of the Institution, a condition of affairs not obtaining some years ago. His year of office, he said, had not modified his opinion that the informal meetings were a valuable part of the Institution's work. With regard to the summer meeting, he thought the conferring of honorary degrees on two of the representatives of the Institution reflected its importance. The number of books borrowed from the library spoke well for the increasing interest of members. On the adoption of the report being accepted unanimously, Mr. Raymond Crane, F.C.A., was appointed to audit the accounts of the Institution for the coming year. The ballot for the election of officers resulted as follows :—President : Mr. Loughnan St. L. Pendred. Vice-Presidents : Professor W. E. Dalby and Mr. Charles Day. Members of the Council : Mr. Cecil Bentham, Mr. S. B. Freeman, Professor F. C. Lea, Mr. R. E. L. Maunsell, Mr. J. F. Petree (Associate Member), Mr. W. A. Stanier, and Sir John E. Thornycroft. The following Past-Presidents were also appointed to serve on the Council :—Dr. D. Adamson, Mr. R. W. Allen, Mr. W. Patchell, and Mr. W. Reavell, and the chairmen of the local branches were co-opted in the same capacity.

The President then announced that the Council had conferred an honorary life membership on Dr. H. S. Hele-Shaw as a recognition of his scientific attainments, and also on Baron Chuzaburo Shiba, of Tokyo, who had taken a prominent part in the recent Engineering Congress at Tokyo, which had been attended by Mr. R. W. Allen as the Institution's delegate.

At the conclusion of the business meeting, Dr. Adamson vacated the chair in favour of the newly-elected President, Mr. L. St. L. Pendred, and in doing so, said it was unnecessary to introduce Mr. Pendred formally, as he was well known to all the members present as the editor of one of the leading engineering journals, with a world-wide reputation. Mr. Pendred had been a Vice-President for five years, a member of Council for ten years, and had joined the Institution in 1896. Before resigning the chair, however, Dr. Adamson said he would like to express his thanks to the staff for the real help he had received from its members.

METALLURGIA

The British Journal of Metals.

Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

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CONTENTS

METALLURGIA

THE BRITISH JOURNAL OF METALS.

The National Fair.

In the last issue of Metallurgia it was only possible to refer somewhat briefly to the Birmingham Section of the British Industries Fair, in which readers of this journal are more particularly interested. Useful as an advance review undoubtedly is, it can only serve as a preliminary to a more comprehensive consideration of the many metallurgical aspects associated with a successful Exhibition of this character. The value of correlating the various exhibits after they have been subjected to inspection, and giving them their right perspective is very real; further, it facilitates in defining the progress of metallurgical activities in meeting the increasing demands for alloys that will withstand the speed and durability tests to which they are subjected and which effects a multitude of operations involved between the production of the metal or alloy and the finished engine, machine or structure. Such a post-exhibition review enables the significant features to be emphasized, to indicate the progress being made, and to assist in maintaining valued impressions that have been formed by those who visited this section of the Fair.

A National Fair serves a very useful purpose, not so much in showing new inventions, but in exhibiting developments and improvements upon which industry depends. It is the character of the develpoments that indicate the degree of progress attained; new ideas are rarities and are frequently associated with difficulties that are apparently unsurmountable. Whether new ideas are in the form of alloys or machines, it is the further developments, frequently resulting from intensive research work of an experimental character, that are responsible for the gradual elimination of difficulties to facilitate their application. Thus, it is the continued improvement and development of products to pass all reasonable tests, within the purposes for which they are designed or manufactured, that indicate the degree of progress attained.

At Castle Bromwich the Exhibition was referred to as the heavy section, but typical forms of rolling-mill equipment and other heavy machinery associated with the heavy production side of engineering were very scarce, which is rather unfortunate at a National Exhibition of this character, and many expressed regret that machine tools should have taken up so little room. It seems to be an excellent opportunity for united action on the part of manufacturers and producers to concentrate in an effort to display to the world the progressive spirit that pervades the British industries and the enormous capacity for coping adequately with any engineering problem, however complex, in a manner which, from point of view of design, workmanship, utility, stability and cost, would compare favourably with the products of any other country. There is no doubt however, that, as a National Fair, it is gripping the imagination of the manufacturer, and just as this Exhibition was in advance of its predecessor, there is every indication that a further advance will be noticeable at the next Fair, and in numbers of exhibitors and variety of exhibits we are likely to see future National Fairs that will be more representative of the resources of British industry.

It is significant of the determination of British industry to maintain and increase its prestige in the world's markets that a committee should have been set up by the Board of Trade to consider what means can be adopted to increase still further the utility of the British Industries Fair to British trade. This committee, the chairman of which is Viscount Chelmsford, includes among its members Sir Wm. J. Larke, of the International Federation of Iron and Steel Manufacturers, Mr. Guy Locock of the British Federation of British Industries, and Sir Gilbert Vyle, of the Association of British Chambers of Commerce, and its terms of reference will comprise the possibility of extending the scope of the Fair, the desirability of holding a second Fair in the autumn, the possibility of holding sectional Fairs, and also of organising travelling Fairs, either in ships or trains. There has been a move in certain quarters to concentrate future Fairs in London, but it is unlikely, if not impracticable, that the heavy section will be moved from Birmingham. It is to be hoped that the Board of Trade Committee will consider the possibility of planning future Fairs so that there will be fewer obstructions, and also that they will be sectionalised so that visitors will not have to walk many miles before they at length reach that which interests them.

BLAST FURNACE PRACTICE.

It has been said that the success of the blast furnace can only be secured if it is supplied with ore of the right character, both from a chemical and a physical standpoint; limestone and other fluxes of the proper quality, and fuel of the right size, strength, and composition. It is no doubt due to the remarkable uniformity of quality of the raw materials in the United States that such important developments have been made in that country during recent years. All the circumstances have apparently combined to facilitate big production. In addition to uniformity in quality the ores used have relatively high iron contents, factors recognised as of the greatest importance in economical production. The ores are carefully graded, and materials of varied value are mixed to give a more regular quality; there is ample coal available, which can be coked satisfactorily in modern by-product ovens, and another important factor is the big home market for her products. In making comparisons, it must be remembered that the bulk of the ore mined in this country is of low grade, and the ores from different districts, and even from the same district, vary much in their character. Thus, not only is the quantity of ore greater for a given production, but the variability of the available raw materials is a very real factor retarding production on a comparative basis. Methods corresponding to those in operation in the United States have been tried in this country, but the conditions are so different here that the experiment did not meet with the success anticipated.

The blast furnace may be termed the largest industrial producing plant in modern times, and although dependent for its success primarily upon the factors previously mentioned, other factors must also be considered adequately to have complete success. The economical production of iron is a very complex operation, and is the

combined result of so many different influences, all of which are subject to variation, and the divergence of any one of these influences, beyond the recognised working limits, may interfere with the normal conditions, and, in consequence, operate against normal production. From these working difficulties problems of varying importance arise which frequently tax the skill and knowledge of the furnace manager to determine the cause and to devise and apply remedies. Each difficulty must be met according to the circumstances under which it arises and the manner in which a problem is solved is frequently dependent upon the particular plant. Each furnace has its own idiosyncrasies, as circumstances which produce a given result at one furnace, when repeated at another furnace of the same group may, and indeed probably will, not cause the same result. It is due to this peculiarity that furnace managers have asserted that a method may give successful results on another plant, but is impossible with the plants they operate. While this is true, it is still helpful to examine possible improvements in the scheme of operations. As our contributor states in his introductory remarks on the "Modern Blast Furnace and its Operation," the adjustment of some apparently small item in design, manipulation, burden, constitution, etc., in these days of keen prices, may make all the difference between a credit balance on the one hand and a loss on the other.

INSTITUTE OF METALS.

ANNUAL MEETING.

THE annual meeting of the Institute of Metals is always one of the most interesting as it is one of the most important technical meetings of the year, and at the 22nd annual meeting which was held on March 12 and 13, a number of interesting papers were read. The importance of the work of the Institute of Metals, especially in regard to non-ferrous metallurgy, cannot be over-estimated.

The new President of the Institute who succeeds Dr. W. Rosenhain is Dr. R. Seligman. Dr. Seligman has had a distinguished career, and after spending many years in research work, formed the Aluminium Plant and Vessel Co., Ltd., in London in 1909, and has since largely devoted himself to the development of aluminium in the service of industry, originally in the welding processes which enabled large-scale plant to be devised, and latterly in the associated technological work involved in its use in the foodstuffs, chemical and other industries. Dr. Seligman is a worthy successor of Dr. Rosenhain.

In the Council's Report of the Institute of Metals reference is made to the preliminary Conference that will probably take place in London for the purpose of discussing the possibility of forming an International Metallurgical Research Organization with the object of securing closer co-operation in the future between the Continental and the British Metal Institutes. Another interesting development referred to is the decision to participate in the erection of a joint building for the purpose of housing a number of scientific and technical societies which at present are scattered in offices in various buildings in different parts of London and the provinces. The scheme for a joint building originated with the idea that the principal metallurgical societies should be accommodated in a single building, but it has now been extended to include a number of other societies. The scheme has now progressed so far that substantial financial contributions have been promised from a number of sources, and it is probable that the erection of a building on a suitable site will be commenced in the near future.

During the past year the Institute of Metals has added one name to its list of honorary members, that of Professor D. G. Tammann, the doyen of German metallurgists, and in doing so, has honoured itself. Because of the eminence of their services to the Institute, and in commemoration of its Coming-of-Age, the Council have elected as Fellows the late president, Dr. W. Rosenhain, F.R.S., and the six surviving past-presidents :—Professor Sir Harold Carpenter, Kt., M.A., Ph.D., A.R.S.M., F.R.S.; Sir John Dewrance, G.B.E.; Ebgineer Vice-Admiral Sir George Goodwin, K.C.B., LL.D.; Engineer Vice-Admiral Sir Henry J. Oram, K.C.B., F.R.S.; Leonard Sumner, O.B.E., M.Sc., and Professor T. Turner, M.Sc., A.R.S.M.

Corrosion research has resulted in many discoveries of great value to the engineering, shipbuilding and kindred industries, and splendid work has been done by the Corrosion Research Committee of the Institute of Metals since 1910. Henceforth, the work will be controlled and directed by the British Non-Ferrous Metals Research Association, and will be continued on its present general lines by Mr. R. May A.R.S.M., working in the laboratories of the Royal School of Mines. It is understood that the sub-committee responsible for the work will include a strong representation of the Institute of Metals, and if possible, of some of the users of condenser tubes, who have been members of the Corrosion Research Committee.

The annual dinner of the Institute of Metals was held on March 12, in London, Dr. Richard Seligman being in the chair.

Forthcoming Meetings

INSTITUTION OF MECHANICAL ENGINEERS.

Mar. 21. General meeting. "The Design and Results of a 600-lb. per sq. in. Boiler Installation," by Wm. Nithsdale, B.Sc.

JUNIOR INSTITUTION OF ENGINEERS.

Mar. 21. "Surface Combustion," by M. V. Hurst.

Mar. 28. Sixth Quadrennial Gustave Canet Memorial Lecture. "Industrial Accidents: Their Cause and Prevention," by G. Stevenson Taylor, O.B.E.

INSTITUTE OF METALS (BIRMINGHAM SECTION).

Mar. 18. "Nickel-Chromium Alloys," by W. R. Barclay, O.B.E.

Mar. 18. North-East Coast Section. Annual general meeting. Short paper competition.

Apl. 10. London Section. Annual general meeting. Open discussion.

Apl. 10. Sheffield Section. Annual general meeting. "Refractories and Their Uses," by F. Russell, F.G.S.

THE INSTITUTE OF BRITISH FOUNDRYMEN.

Mar. 21. Birmingham Branch. "Efficiency in the Core Shop," by F. H. Hudson.

Apl. 5. Annual general meeting. Lancashire Branch. "Some Aspects of Foundry Service to the Engineer," by E. J. L. Howard and H. Milner.

Mar. 29. Newcastle-on-Tyne Branch. Visit to works of Wallsend Slipway and Engineering Co., Ltd., during afternoon. In the evening a paper entitled "Moulding in a Jobbing Foundry," by A. Sutcliffe.

Mar. 22. Scottish Branch. Annual general meeting. Presentation of "John Surtees" Medal. "The Foundry and Its Problems," by H. Hurst.

Apl. 5. Wales and Monmouth Branch. Annual general meeting at Cardiff.

INSTITUTION OF AUTOMOBILE ENGINEERS.

Mar. 17. "Combustion in Diesel Engines," by H. R. Ricardo, at the Royal Technical College, Glasgow.

Mar. 26. "Some Problems in the Design of the Golden Arrow," by Capt. J. S. Irving, at the Engineers' Club, Manchester.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Apl. 4. "Ships' Auxiliary Machinery," by A. Read.

THE INSTITUTION OF WELDING ENGINEERS.

Apl. 10. "Some Interesting Arc Welded Jobs," by H. B. White and R. Tuddenham.

INSTITUTE OF MARINE ENGINEERS.

Apl. 8. "Recent Metallurgical Research in Relation to Marine Engineering," by S. L. Archbutt, F.I.C.

Drop Stamping Non-Ferrous Alloys

By K. Napier.

THE shaping of non-ferrous alloys in dies by means of drop stamping is not new, but it is a fairly recent development from the drop stamping of steel. Brasses and bronzes have been fashioned to shape in dies for many years by the process known as hot pressing, and while this process is similar in some respects to actual drop stamping, it has many differences. As a rule, only articles of a simple and straightforward design are made by this process, and the presses generally consist of a relatively slow-moving plunger to which is fixed a die. The material is placed in the bottom die, and the top die is forced on to the hot metal, when the required shape is achieved in one blow, as a rule. The majority of such parts are made from round bar, and it is very rare that any preliminary forging is done prior to the stamping. It is evident, therefore, that there is a vast difference between hot pressing and drop stamping, for the effect of the rapid blows of the drop hammer are different from the relatively slow plunging of the other machine, and, moreover, the design of the drop-stamped articles may be very different from the hot-pressed article. In many other obvious ways the two processes differ very greatly, and so drop forging of these alloys necessitates separate consideration.

Alloys Having Specific Tenacity.

There is no doubt that the comparatively recent realisation of the great value of aluminium alloys has had much to do with the inception of the drop-stamping of non-ferrous alloys in general. The fact that some of these alloys possess what has been called a high specific tenacity—*i.e.*, great strength for a low weight—has brought to light the truth that they are extremely valuable for the manufacture of component engineering parts where strength coupled with lightness is essential. Such alloys are also particularly good conductors of both heat and electricity, and because of these properties they are destined to be greatly used. Again, it is computed that more than half of the solid matter of the earth is composed of material containing aluminium in combination. It only remains for a commercial method of extracting the metal to be discovered when aluminium alloys will constitute a serious rival to steel and iron. Doubtless this discovery will take place sooner or later, and so everything points to the future enormous development of the drop stamping of non-ferrous alloys.

The high price of copper-bearing alloys tends to limit the utilisation of drop stampings in them very considerably. There are, however, many uses to which these alloys are put, and although stainless steels are tending to oust non-ferrous alloys to some extent there is no doubt that such parts in the form of drop stampings will continue to be required in very considerable quantities.

It is convenient to split the drop stamping of non-ferrous alloys into two parts, the first dealing with copper-base alloys, and the second with aluminium-base alloys. Although there is something in common in the using of the two classes of materials, it is more convenient to consider them separately. Of copper-base alloys the first is copper itself. The main quantity of copper stampings are made from the purest brands of copper obtainable. This is due to the fact that a large percentage of such stampings are required for electrical work, and as the electrical conductivity of copper is seriously affected by the presence of even small proportions of impurities, this class of work demands the purest copper obtainable. Occasionally, copper stampings are required which are somewhat harder than those in pure copper, and to effect this small additions of such elements as iron, arsenic, and aluminium are made. Whilst these elements harden the metal they do not affect them from a drop-stamping viewpoint, and so all of these alloys can be considered together.

Importance of Temperature Control.

Copper is an excellent conductor of heat, which means that whilst it is very conveniently heated it is also equally prone to loose its heat. It therefore behoves one to be as quick as possible when stamping this metal. Fortunately, it is capable of being stamped to some extent when it has dropped considerably in temperature, but cold working must not be carried to excess. The most important feature of the drop stamping of copper, as of all non-ferrous alloys, is temperature control, and it is a very difficult matter to persuade stampers to use temperatures which are very much below the correct stamping temperatures of steel: especially is this so when the stampers have been accustomed to stamp steel. Moreover, it will generally be found that stampers are averse to utilising temperaturse which are controlled by means of pyrometers; they are frequently found to be sceptical of such instruments, and believe that they are quite capable of correctly estimating temperatures by means of their naked eyes. This popular impression is the cause of very considerable waste, because it is safe to say that by far the greatest number of failures with non-ferrous alloys in stamping is due to them becoming overheated at some stage of their manufacture. Pyrometric control is essential in the stamping of all non-ferrous alloys, and it is only when such instruments are installed that consistently good results can be expected. It may be noted, however, that there is a distinct tendency for pyrometers to be looked upon as being a universal panacea for all troubles. It is clear that a pyrometer only registers the temperature obtaining at the end of the rod, and so common sense is essential in seeing that the remainder of the furnace is at the same temperature as that of the end of the rod. It cannot be said that because the pyrometer reading is correct there is no danger of the articles being overheated. Furthermore, it is necessary to remember that a stamping shop is subject to considerable vibration, and either a specially adapted pyrometer should be used or else particular care must be taken to ensure that the indicator is insulated from vibration.

Factors in Copper Stamping.

Copper being an expensive metal, it is obvious that there cannot be more than a minimum of failures if commercial success is to be the result. In view of this, hot stamping is to be preferred to cold stamping. It is possible to make copper stampings when cold, but there is danger of the material becoming over-cold worked, and cracking may result. Moreover, if cold stamping is done, several intermediate annealings are rendered necessary, and this is expensive and also wastes considerable time. Again, hot copper will flow much more easily into complicated dies than it will when cold, and so excessive stamping is avoided. This will prolong the life of the dies, and will reduce the number of failures due to the non-filling of the impression.

On the other hand, there is a further point of importance, which is, that copper stampings have generally to be machined. Copper is not an easy material to freely machine, the tendency being for the metal to tear rather than cut crisply. To ensure free cutting, a certain amount of hardness is necessary which is not forthcoming after either free annealing or total hot stamping. It can be managed, however, by doing all the preliminary stamping hot and merely finishing in the cold or nearly cold condition. In this way the flow is ample when hot, and yet a certain amount of cold working is obtained on the surface which is sufficient to harden it slightly and so make machining more easy.

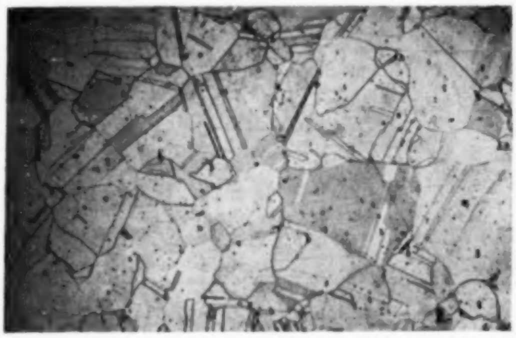


Fig. 1.—Large Grain of Alpha Alloy due to Overheating.

The stamping temperature of copper is approximately 650—700° C., and this range should be aimed for. A slight increase above this temperature will do little harm, but if the increase be great there is danger of spoiling the part. The effect of the increased temperature is that the grain size of the material is liable to become very large (see Fig. 1), which has the effect of reducing its tenacity and rendering it practically impossible to obtain a reasonable test specification: this applies to most metals and alloys with an "alpha" structure. Provided the extra heating has taken place before work is finished, it is possible to break up the enlarged structure again by means of more work, but this can only be done if the over-heating has been of a mild degree. If very much overheated, the copper will melt, for the melting point of copper is considerably less than that of steel.

Type of Furnace.

The type of furnace used for the heating of copper is important for several reasons. The first is that overheating will spoil the element, whilst the second is that coke-fired furnaces are far from ideal. Coke gives off a certain amount of sulphurous gases which are readily absorbed by pure copper, with the formation of copper sulphides. These substances are extremely deleterious in their action on copper, and so coke furnaces should be avoided. Quite the best type of furnace is the electric, whilst a coal-gas furnace is also good. It is a helpful plan to place sheets of scrap steel round the copper so that there is no danger of the actual flame impinging on the metal. Oil-fired furnaces may also be successfully used for the stamping of copper, and again much the same precautions are necessary to prevent the metal being burnt, and also to prevent the absorption of undesirable gases. It should be noted that copper is susceptible to the effects of oxygen, which gas easily combines with the hot metal. On the other hand if all the oxygen be taken from the metal an equally undesirable result is forthcoming. Hence we see that both an oxidising and a reducing atmosphere are bad, the former because it is prone to admit oxygen into the metal, and the latter because it is liable to extract too much oxygen from the metal. The ideal is obviously the neutral atmosphere, and this should be approached as nearly as ever possible.

Scale is practically entirely absent from copper, and so this helps stamping being done without the aid of a lubricant. With most designs of stamping lubrication can be dispensed with, and this is advantageous, in that oil and other common lubricants tend to produce an unsightly black skin on copper, which is ofttimes difficult to remove. To assist in dispensing with lubricant, it is well worth while to spend some time in the finishing of the dies. If the impression be made smooth the metal will flow much more easily into the smaller portions of the design. Hand finishing and burnishing of dies is expensive, but it is probable that in this case it is justifiable.

So far as contraction and expansion allowances are concerned there is no special necessity to make provision for these more than is done for steel stampings. As, however, copper is to be stamped without the use of lubricant, a slightly increased allowance for draw will assist in the easy removal of the stampings from the dies. This is not without importance, because it is evident that if a stamping should stick in a die it cannot be forcibly removed in the manner adopted for steel stampings, as such harsh treatment will doubtless bend the soft metal completely out of shape. On the other hand, it is equally true to remember that such easing of the dies cannot be carried to excess, for the reason that copper is an expensive metal, and one cannot afford to make the stampings too heavy from the cost point of view.

Choice of Material.

Any reasonable stock material is suitable for these stampings. Rolled or extruded bar is probably the best, but cast ingots can be used provided they are sound. Good copper castings of any sort are not easy of manufacture, and of course any original flaws present in an ingot will show up in the final stamping. It is for this reason that worked material is to be preferred to cast material. In this connection it may be mentioned that one occasionally hears of non-ferrous castings being made which are subsequently placed in dies and stamped. It may be that in certain instances this process is of advantage, but it does not seem to be so in this case. Copper castings are not easily made, and apart from this the expense of casting followed by stamping is a very expensive process of manufacture.

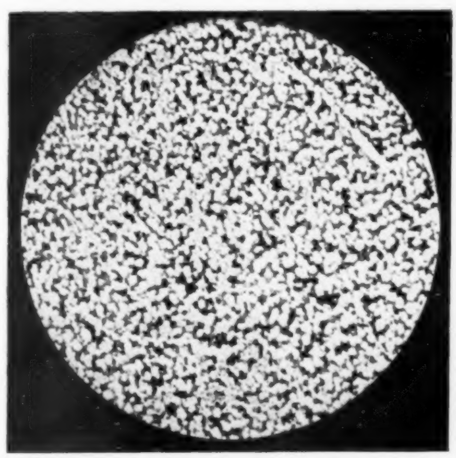


Fig. 2.—Hot Stamped Alpha-beta Brass.

In the event of copper forgings becoming discoloured, it is usually a simple matter to remove the tarnish by means of simple pickling. This may be accomplished with the ordinary strengths of sulphuric acid solution in water. When the bath is hot the process is much quicker than when cold, and the addition of a small percentage of commercial potassium bichromate solution assists in the obtaining of the typical salmon pink colour.

The stamping of brasses and bronzes is in many ways similar to that of copper. It is not uncommon to receive inquiries for stampings made in all sorts of non-ferrous alloys which will not hot-work at all, or if they will it is only with difficulty. Gunmetal stampings are sometimes required, but whilst this mixture is excellent for casting, it cannot be subjected to hot work, for the reason that if such be attempted the alloy will fall to pieces. The same applies to the common classes of phosphor bronzes, and, in fact, to the majority of alloys which contain other than the alpha and beta constituents.

Constituents of Manganese Bronze.

It is perhaps not generally appreciated that non-ferrous alloys suitable for stamping can be obtained which will give mechanical properties equal to those obtainable from good quality medium carbon steel. These alloys contain aluminium, iron, manganese, and occasionally tin, in varying proportions, in addition to copper and zinc. The majority of these alloys contain between 0·50 and 1·0% iron, 0·5 and 3·0% aluminium, and up to 1·5 to 2·0% manganese. The zinc content is the remainder after allowing for 57·5 to 60% copper. These latter alloys are generally known as high-tenacity bronzes or brasses (the terms "brasses" and "bronzes" are used so loosely to-day that it is difficult to be dogmatic as to which is one or the other), and when the percentages of the elements other than copper and zinc approach the higher limits mentioned, the tensile strength of the resulting alloy increases accordingly until a maximum of approximately 48 tons per square inch is achieved. These latter alloys may be looked upon as being somewhat superior to the more common type of hot-working bronze, and are rather more expensive and difficult to work than the common hot-stamping brass, which is an alloy of about 60% copper and 40% zinc, consisting of alpha and beta constituents (see Fig. 2). Up to 3·0% of lead is sometimes added to this latter mixture, its effect being to cheapen the alloy and to render the stamping more easily machineable.

Comparisons.

The "straight" 60/40 type alloy is more easily stamped than are the more complex alloys, the reason being that

Fig. 3.—Normal Structure of Manganese Bronze.

they are softer at the correct stamping temperature, and so flow more easily into the dies. Furthermore, it is more easy to obtain a good structure with the simple alloys than is possible with the complex ones. This is due to the fact that those alloys which contain aluminium and manganese are prone to grow in size of grain to an extraordinary extent if they are overheated to any great extent. The manganese forms a compound which acts as a nucleus for the crystals to grow, and it is not uncommon for crystals of the size of a small pea to be formed when too high a temperature is reached and little breaking up of the structure is possible by means of further hot working (see Figs. 3 and 4). The reason for very careful regulation of stamping temperatures is therefore made apparent, and it is even more imperative to control these temperatures than is necessary for copper. Pyrometers are obviously a necessity, and their use cannot be too strongly advocated.

For the preliminary forging a temperature of 650° to 750° C. can be used, as whilst the alloy is not very soft at this temperature the heavy forging hammer will effectively work the material to shape and the grain size will be kept within due bounds. For the stamping, however,

Fig. 4.—Manganese Bronze after Overheating.

it is better to increase the temperature slightly, so as to make the alloys more soft and more free to flow into the dies. At the highest, however, 720° C. should not be exceeded for the high tenacity alloys, whilst 750° is amply high enough for the more common alloys. In any case, it is preferable that the finishing temperature be kept as low as possible. This frequently follows in the ordinary course of events, as the temperature naturally falls as the stamping proceeds, but if the finishing temperature is seen to be on the high side, it is a good plan to ensure that the last portion of the work is done when the temperature is in the neighbourhood of 650° C. The need for exacting temperatures has been somewhat stressed, but it cannot be too carefully stated that the mechanical properties of non-ferrous stampings depend largely upon their grain size, and the smaller it is the better are the properties forthcoming. It is also to be realised that if the temperature has been too high and the grain has grown accordingly, it is not possible to remedy the trouble by means of heat-treatment, which may be so conveniently done with steel which has become coarsened by overheating.

The size of brass stampings is generally small, and it is rare that long stampings of small section are required. Because of this the allowances for draw and expansion and contraction need little consideration, and it is further clear that as these alloys are very expensive it is not good commercial practice to make the draw allowance too great, for this results in the parts becoming too heavy and waste of material occurs when this excess has to be machined off. So far as provision for the lubrication of dies is concerned, it may be said that whenever it is possible to dispense with the use of any lubricant this course should be adopted. The theory of the lubrication of drop-stamping dies is that a substance is used which will mildly explode when subject to the heat of the stamping. Thin oil is therefore a common substance which is used in this way. It is evident, however, that owing to incomplete combustion of the oil, and to the presence of considerable foreign material, dies generally become very dirty. When this dirt is attached to the skin of the stamping it gives it an unpleasant appearance, which is not desirable, and so the use of oil should be dispensed with entirely when possible. Intelligent manipulation of the stamping hammer will go far in ensuring the making of good stampings without the necessity for lubricant; especially is this so when the dies are smoothly finished.

(*Continued on page* 214.)

The Modern Blast Furnace and its Operation

By R. A Hacking, B.Sc.

The prime object of the blast furnace is not to make pig iron, but profit, and proposed alterations in any of the many factors must always be strictly scrutinised from an economic standpoint. Transport charges play a predominant part in determining the choice of raw materials available ; thus it must be left to the individual operator as to which modifications are economically possible at his particular plant. It does not always follow that an improvement in technique is accompanied by a corresponding gain on the financial side. One has experience of circumstances where the relative costs of the various raw materials have recommended the use of an increased proportion of lean ores, resulting in financial benefit, in spite of increased fuel consumption and a decided step back from a technical standpoint.

In a series of articles it is proposed to deal separately with the theoretical aspects of the main tendencies in modern blast-furnace operation, in an endeavour to determine the relative merits of each.

THE conditions which obtain in the blast furnace industry at the present time render it imperative that operators should be constantly on the look-out for weak points and possible improvements in the scheme of operations at their respective plants. The adjustment of some apparently small item in design, manipulation, burden, constitution, etc., in these days of keen prices, may make all the difference between a credit balance on the one hand and a loss on the other.

Many of the factors constantly to be borne in mind by the blast-furnace operator are dependent upon local conditions, and as such are best left to the man on the spot. In many cases, especially where home ores are used, the factors which govern the economy of the process are constantly changing, and should therefore be subject to frequent review and revision by the technical staff. In addition to such "local" factors, several developments of a more general nature—such as improved "combustibility" of the coke, greater "reducibility" of the ores, etc. —are occupying the attention of scientific workers in this country, in the United States, and on the Continent.

Many blast-furnace managers are frankly sceptical of some of the claims and results put forward by research workers and theorists, and sometimes one point is selected from the many without an impartial survey of the whole, and exploited in order to account for shortcomings in the past, and conservatism in certain directions in the present. Thus, it is often found, in composite plants comprising coke ovens, blast furnaces, etc., that the blast-furnace manager points to improvements in the "combustibility" of the coke as the surest and quickest means to more economical production of pig iron, whilst the coke-oven manager retaliates by suggesting that the "reducibility" of the ores is the weakest link in the chain.

The first object of this series of articles is to endeavour to survey the present situation in the proper perspective, and, by analysis of each factor in turn, to obtain some idea as to the relative advantages to be gained by application of the modifications proposed.

The thermal aspect of the subject will be dealt with first, leaving the consideration of the chemical principles until later in the series. It must be realised, however, that the two are closely interdependent, and the one cannot be adequately discussed without frequent reference to the other. At the outset, a brief outline of the history of blast-furnace development is advisable.

Historical.

The application of counter-current principles to the blast furnace dates from about the fifteenth century, when by the addition of a truncated cone-shaped extension to the top of the hearth the forerunner of the modern shaft was first utilised. It is probable that this extension was added in the first place from thermal considerations only, in order to impart some degree of pre-heat to the ore and the fuel before reaching the hearth. The fundamental changes in operating conditions and character of product must, however, have shown those early operators that considerable resultant alterations of the chemical principles of the process had been brought about.

Progress in design and operation was comparatively slow until the beginning of the eighteenth century, when the use of coke as a fuel was introduced. Later, the invention of the steam engine, and its application to industry, led to greatly increased demands for pig iron, and stimulated the efforts made with a view to increased capacity and efficiency of the producing units. The beginning of the nineteenth century saw the commencement of a period of rapid development of the blast furnace, and since then progress has been more or less continuous up to the present day.

Prior to the year 1828, development had occurred simply by modifications of the first step taken in the fifteenth century—namely, by alterations in the dimensions of shaft and hearth. In that year the introduction of the use of hot blast saw the second vital step in the efficient utilisation of the blast furnace as a counter-current heat machine. The great economies effected by Neilson's invention led to its extensive adoption, and for the remainder of the nineteenth century development was along the lines of increased dimensions and output capacities, higher blast temperatures, and alterations in the equipment and proportions of the furnaces to meet the new thermal, physical, and chemical conditions.

The researches of Sir Lowthian Bell, culminating in the publication of his classic work in 1884, commenced an era of inquiry into the thermo-chemistry of the blast-furnace process. Most of the investigators of that period endeavoured to account for observed working results from a survey of balance-sheets, where only the numbers of thermal units required by each chemical and physical change were expressed.

The temperature of application of the heat input received scant attention. A counterpart of such a view would be to attempt to calculate the power in an electrical circuit, knowing the amperage only, and not the voltage ; or in a quantity of steam, knowing only the amount of the latter, and not the pressure. Consequently, the economies effected in practice by the adoption of Neilson's invention remained something of a mystery for many years.

In 1905 J. E. Johnson advanced his theory of "Critical Temperature," in which the vital importance of the intensity of temperature attained in the hearth was recognised and defined. Whilst one or two earlier observers had in some degree recognised that the thermal intensity, as distinct from the rate of supply of heat units, was of importance in the maintenance of the requisite hearth conditions, Johnson was the first to express its true significance. Calculations based on his theory gave results which approximated to the hitherto unexplained economies

effected in practice by the use of hot blast, thus providing for the first time an adequate quantitative explanation of a much-discussed phenomenon.

Johnson's theory may be briefly stated as follows :—

"For maximum fuel economy there are two principal laws :—

(1) Each pound of fuel must develop the maximum possible amount of heat.

(2) A certain irreducible proportion of this must be developed above the critical temperature, which is the free-running temperature of the slag."

The following suggestions were put forward by Johnson as means to the accomplishment of this end :—

(*a*) Impart as much total oxygen as possible to each unit of carbon before it leaves the top of the furnace.

(*b*) Burn the largest possible proportion of carbon with oxygen from the blast.

(*c*) Heat the blast as hot as possible.

(*d*) Remove the moisture from the blast as fully as possible.

(*e*) Keep the free-running temperature of the slag as low as possible, since a decrease in the critical temperature has a greater effect than an equal increase in blast temperature.

(*f*) Keep hearth requirements low by keeping down slag volume and avoiding excessive cooling for protective purposes.

(*g*) Above all, secure a stock distribution which will ensure minimum solution loss with uniform preparation and descent of the charge column, so that no work which can possibly be done in the shaft will be left to be done in the hearth.

(*h*) Even following these rules, the hearth heat is generally deficient as compared with the shaft heat, and therefore, except in certain special cases, the heat consumption of the shaft can be increased within reason, without much, if any, loss of efficiency by the furnace as a whole.

Whilst some of these rules are perfectly true, experience subsequent to Johnson's work has demonstrated that several of the above conclusions—especially (*b*) and (*d*)—are not wholly correct. These points will be dealt with at a later stage.

In recent years, Johnson's theory has been amplified by Korevaar, who has formulated "The Law of Heat Compression." This states that by compressing or localising the heat in the furnace, a higher temperature with given carbon consumption, or conversely, a given temperature with lower carbon consumption, may be maintained. Assuming that the composition of the pig iron and slag, and the weight of the latter per ton of pig iron, remain constant, the factors which determine the degree of "heat compression" in the blast furnace—that is, the volume and temperature of the combustion zone—are as follows :—

(*a*) The carbon factors—namely, the activity, porosity, size, and freedom from foreign matter, of the fuel in the hearth.

(*b*) The air factors—namely, the velocity, temperature, oxygen content, and moisture content of the air entering through the tuyeres.

(*c*) The furnace factors—namely, the dimensions and design of the furnace, and the thermal properties of the constructional materials.

All the developments which have led to the increased efficiency of the blast furnace since counter-current principles were first applied, have aimed deliberately at, or have attained incidentally, the improvement of one or more of the items enumerated above.

In looking back over the history of blast-furnace development, one very definite tendency has prevailed in the quest for fuel economy—namely, the endeavour to reduce the weight of blast entering the tuyeres,—and consequently the weight of gases leaving the hearth and passing up the shaft, per ton of pig iron. At first sight, this would appear to follow directly from the fuel economy effected by each progressive step. Such is not wholly true, as will be shown later in a review of the thermo-chemistry of the reactions between iron oxides and carbon and its oxides.

Analysis of Blast-furnace Development.

In the early days of the iron industry the amount of cold blast used per ton of product was naturally very high, and consequently the volume of hot gases leaving the hearth was excessive. Recognition of this fact led to the adoption of the shaft, and the application of the counter-current principle. Thus, the first step was not to lessen the gas volume directly, but, regarding the magnitude of this factor as inevitable, to provide means by which some of its energy might be utilised. Improvement then occurred by lengthening the shaft, the longer period of contact thus increasing the facilities for thermal interchange between ascending gases and descending solids. Utilisation of the heat units available in the ascending gases, however, remained very incomplete, and the cold-blast furnaces worked with very hot tops as a result.

The application of hot blast effected a drastic reduction of the blast volume, and consequently of the gas volume, per ton of pig iron. The maintenance of the correct head of temperature in the hearth was effected by the combustion of a much smaller amount of carbon under the revised conditions, and the proportion of heat units carried upwards from the hearth by the hot gases, to the thermal benefit of the materials in the shaft, was greatly reduced.

The "hearth heat," however, still remained much greater than was necessary—or, rather, imparted many more thermal units to the ascending gases than could be utilised in the shaft. The obvious step to overcome this disability was a lengthening of the counter-current. This was effected by progression, until interference with steady driving through mechanical difficulties occasioned by the support of such a high column of charge, called a halt. This point naturally varied in different districts, according to the practice and the quality of coke available.

The simultaneous use of increasing blast temperatures, and consequently of a reduced volume of blast per ton of pig iron, did much to narrow the gap between "hearth heat" and "shaft heat," but here again a point was reached, especially in basic practice, where disturbed continuity of driving appeared to prevent further progress along these lines. It is to these cases, apparently, that Johnson refers when he states that the heat consumption of the shaft—that is, per cent. of the total supplied to, and generated in, the furnace as a whole,—can be increased with economy to the process, except in certain special cases.

There is no doubt that many basic-furnace operators in this country and elsewhere have been confronted with this situation, when, by an increase in blast temperature, and a raising of the burden/fuel ratio *pro rata*, the furnace has commenced to work tight in the bosh, with disastrous results to output, and in most cases to the quality of the pig iron. Most blast-furnace managers who have had this unfortunate experience naturally conclude that the much-sought-after balance between "hearth heat" and "shaft heat" has been attained and even surpassed. The further application of the principles of "heat compression" is held to be unsuited to their particular set of conditions, and faith in the doctrines of Johnson, Korevaar, etc., is severely shaken as a result. The true explanation of such a situation is that one of the factors—namely, the blast temperature—has been increased out of proportion with the remaining factors, such as ore reducibility, slag weight and composition, furnace lines, etc. Modification of a single one of these will often permit of considerable increase in the blast temperature, with resulting greater degree of "heat compression" and fuel economy.

A good example of this is to be found on a certain British plant, where, of two furnaces working on exactly similar burdens, equipped with similar distributors, and producing the same type of pig iron, the one drives freely with a blast temperature of over 100° F. higher than is permissible on the other. A slight difference in the interior lines of bosh and hearth appears to be the only reason to account for this.

(*To be continued.*)

Single-Quenching After Carburising

By WILLIAM F. CHUBB, B.Sc.

Satisfactory results secured from Single-Quenching after Carburising.

OF the many metallurgical advances made during recent years it is difficult to find one which has found such direct application as the process of single-quenching following the normal carburising operation. By single-quenching is meant not the refinement of the core and the hardening of the carburised surface by one single operation of quenching, but the hardening of the case without the necessity of first refining the core. A steel which will respond to such a treatment must obviously have shown no undue coarsening in the core during the prolonged sojourn at the high temperatures normally employed during the carburising operation. It is to the useful influence of nickel in retarding grain-growth at these temperatures, at least when present in sufficient amounts, that we owe the present practice of single-quenching.

General Properties of Nickel Steels.—It is interesting to recall the many useful properties conveyed by nickel. Its general influences are increase of tensile strength, and of resistance to fatigue stresses unaccompanied by appreciable lowering in toughness and dynamic strength, lowering of the thermal transformation points, and, in particular, a lowering of the Ac_3 and Ar_3 transformations by approximately 10° C. for every 1% of nickel present, thereby allowing of less drastic quenching from lower temperatures, and it also lowers the entectoid composition by 0·05% of carbon for every 1% of nickel added.

The Core.—During the normal carburising operation a typical sample of mild steel will display sufficient grain-growth to necessitate subsequent refining of the coarsened core; but it has been shown by research that a minimum of 3% of nickel, with or without additions of chromium, is sufficient to reduce this growth to such low proportions that this refining treatment need not be given. In illustration of this fundamental property Figs. 1 and 2 show, at a magnification of 100 times, the core of a 3% nickel-steel sample before and after carburising, respectively. Clearly, after 10 hours' carburising at 920° C., no appreciable grain-growth is observed at this magnification. A steel in such a condition should therefore need no grain-refining treatment from a temperature slightly in excess of its Ac_3 transformation point, such as would normally have to be given to a casehardening mild steel after subjection to the same or to a similar treatment. A single-quenching, suitably chosen to yield the desired degree of hardness in the case, is the only treatment that need be given.

In order to understand completely the mechanism of this process, it becomes necessary to study in detail the influence of this treatment on the microstructure of both core and case. In photomicrograph, Fig. 3 is illustrated at a magnification of 100 times a steel to the analysis quoted in Table 1, which, after carburising, has been refined at 860° C. and quenched in oil, and then hardened in oil from 760° C. In Fig. 4 is illustrated the structure of a portion of the same bar after quenching in oil from 760° C. only. Whilst no great differences in grain size exist, the single-quenched sample shows a slightly greater amount of free ferrite than is to be seen in the double-quenched sample. This is in accordance with theory, in that the one temperature of 760° C. has been insufficient to absorb all the free ferrite. Predictions in regard to physical and mechanical properties are therefore possible based upon these slight differences in microstructure. The smaller amount of free ferrite in the double-quenched specimen would indicate a higher ultimate breaking strength, a slight reduction in ductility, and of resistance to shock.

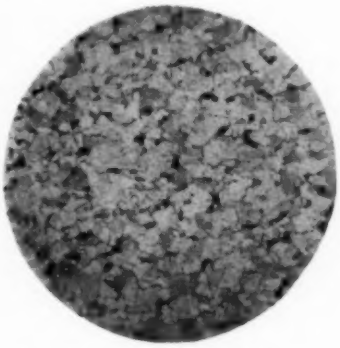


Fig. 1. 3% Nickel Steel, before Carburising.

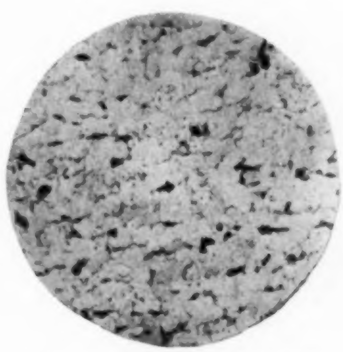


Fig. 2. 3% Nickel Steel, after Carburising.

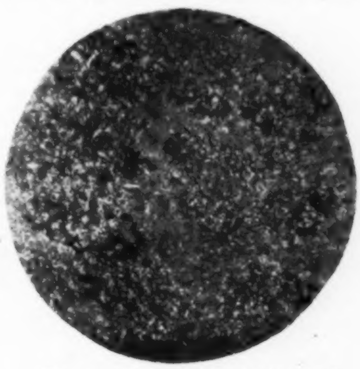


Fig. 3. Core of 3% Nickel Steel, Double-quenched.

These indications find confirmation in the mechanical test figures secured from the two samples and quoted in

TABLE I.

The specimens were carburised and treated as described above:—

Analysis.—

Carbon.	Manganese.	Nickel.	Sulphur.
0·125%	0·56%	3·16%	0·017%
	Phosphorus.	Silicon.	
	0·040%	0·19%	

Mechanical Properties.—Gauge length, 0·564 × 2 in.

	Single-quenched.	Double-quenched.
Maximum stress per sq. in.	48·38 tons	51·70 tons
Yield point per sq. in.	34·60 tons	38·10 tons
Yield ratio	71·7%	73·7%
Elongation in 2 in.	27·5%	26·5%
Reduction of area	63%	60%
Izod impact	81, 82, 81 ft. lb.	77, 80, 79 ft. lb.

Fractures.—(*a*) Tensile, cupped and silky; (*b*) impact, silky and fibrous.

As a further example indicating the properties procurable in a steel of lower carbon and manganese contents the results in Table 2 may be quoted.

TABLE 2.

Analysis.—

Carbon.	Manganese.	Nickel.	Sulphur.
0·10%	0·38%	3·20%	0·038%
	Phosphorus.	Silicon.	
	0·019%	0·20%	

Physical Properties.—

	Single-quenched.	Double-quenched.
Ultimate stress per sq. in.	38·4 tons	39·12 tons
Yield point per sq. in.	28·4 tons	28·6 tons
Yield ratio	74%	73·2%
Elongation in 2 in.	31%	31%
Reduction of area	68%	68%
Izod impact	93, 93, 91 ft. lb.	85, 85, 88 ft. lb.

Fractures.—(1) Tensile, cupped and silky; (2) izod, silky fibrous.

Torsion Tests.—Specimen 0·375 in. diameter by 4 in. parallel.

	Single-quenched.	Double-quenched.
Test mark	E.M. 12	E.M. 13
Torque at elastic limit	208 in.-lb.	240 in.-l.b
Twist " "	2·50°	3·50°
Stress " "	8·9 tons/sq. in.	10·4 tons/sq. in.
Torque at fracture	985 in-lb.	945 in.-lb.
Twist "	940°	960°
Stress "	42·1 tons/sq. in.	40·8 tons/sq. in.
Max. twist per inch length	322°	324°

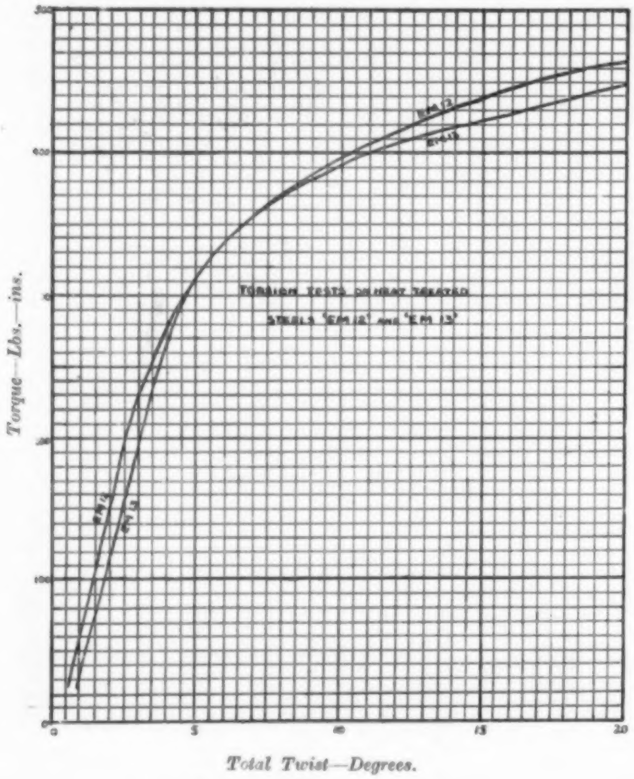
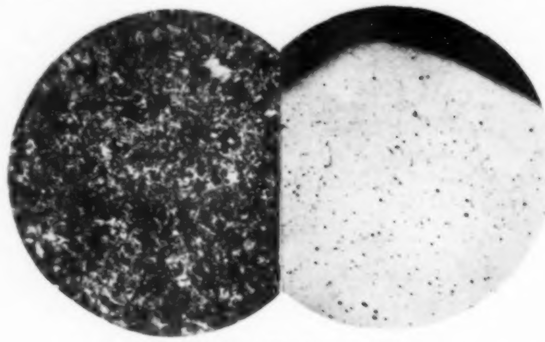


Fig. 5. Torsional Properties. Specimen EM 12, Single-quenched. Specimen EM 13, Double-quenched.

These results are plotted in Figure 5, from which two conclusions seem justified, namely, that no advantage in mechanical properties is to be secured in the core by preferring the double treatment, and, secondly, that since the carbon and manganese contents exert such a profound influence on the physical properties the compositions must be chosen to suit designs. For example, the steel for components of larger cross section should preferably be similar to that in Table 1, and that for components of smaller cross section, such as automobile crown-wheels, should be of relatively low carbon and manganese contents.

The Case.—We must now direct our attention to a consideration of the effects of these treatments on the microstructure of the case, with the object of determining in what manner the carburising operation must be modified, if at all, in order to produce a scientifically treated and therefore consistently reliable component.

At the outset, it must be recalled that the influence of nickel is more dependent on the carbon content than on the nickel content, and also that with the percentage of nickel here needed to retard grain-growth the entectoid composition will have been lowered to some 0·75% of carbon. It follows then that lower carbon contents and shallower depths of case than are employed in carburising mild steels will be needed. This lowering of the entectoid composition will have its effect in greatly enhancing the tendency towards cementite formation. During subsequent treatment this constituent will remain as a network of



3% *Nickel Steel, Single-quenched.*

Fig. 4. The Core. *Fig. 6. The Case, showing Free Cementite.*

undissolved free carbide, since the temperature of 760° C then employed will prove too low to bring about its complete solution. This fact is illustrated in Fig. 6 at a magnification of 100 times. Here the hardened specimen has been boiled in sodium-picrate solution to reveal the pro-entectoid constituent. To avoid this cementite formation three methods of procedure are available, viz. :—

1. Carburising at a lower temperature—*e.g.*, 860° C.
2. Reverting to a carburising compound which, at the temperatures normally employed, produces a minimum of this harmful constituent ; or
3. Carburising in the normal manner, and then following with treatment chosen to diffuse inward any cementite that may have formed.

Of these three methods the first may possibly prolong unduly the carburising operation, and considerations of

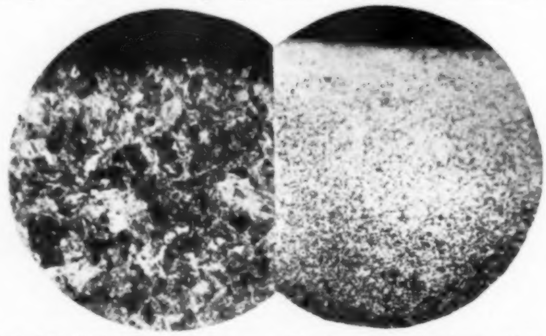


Fig. 7. 3% Nickel Steel, Carburised only. No Free Cementite. *Fig. 8. Same Specimen, Single-quenched, showing Core.*

cost may preclude the use of a more expensive compound. In Fig. 7 is shown the case of a steel carburised in such a way as practically to eliminate this constituent, and Figs. 8 and 9, each at a magnification of 100 times, show the structures after single- and double-quenching, respectively. In these microstructures no essential differences are revealed, and there should be for this reason no great differences in hardness and wearing qualities.

The third remedy lies in a diffusion treatment to follow immediately after the carburising operation. This should be carried out by lowering the temperature of the furnace and its charge as quickly as possible to 800° C., and then soaking at that temperature for 2 to $2\frac{1}{2}$ hours. It should be emphasised that the cooling to 800° C. must be as rapid as possible, since slow cooling secured by merely shutting-off the gas supply to the furnace will only favour the rejection of cementite to the grain boundaries. That this is so is cleverly indicated in Fig. 10, of a steel subjected to this treatment. Here it will be seen that not only is the network coarse, but that the subsequent diffusion has failed to break it down. This photomicrograph should be compared with Fig. 11, at the same magnification, and which represents a 3% nickel steel after proper diffusion. Here it should be noted that the free cementite network has been completely destroyed, and that the small amount of free carbide existing after correct diffusion treatment is in such a form as to be readily soluble during subsequent single-quenching at 760° C.

Now since such a diffusion treatment must of necessity increase the depth of case to a small extent, it is preferable to reduce the normal time of carburising by some suitable amount. For most purposes it should be reduced for about one hour, but the required time must, of course, be determined separately for each component to be carburised.

Summary.—To conclude, it is clear that whilst satisfactory results can be secured from the process of single-quenching after carburising full knowledge of the process must be sought. Only then, as in all other heat-treatment operations, can it be carried out with confidence and certainty.

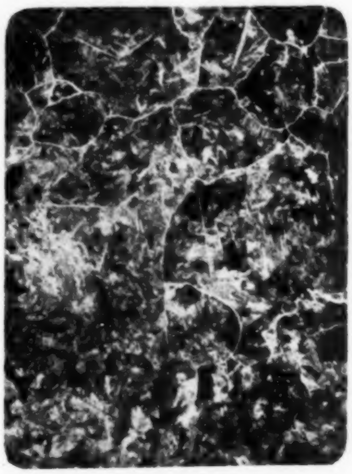


Fig. 10. Incorrectly Diffused Case.

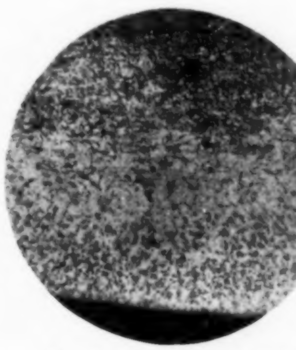


Fig. 9. Correctly Carburised and Double-quenched.

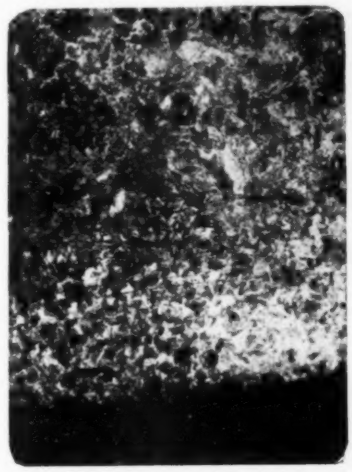


Fig. 11. Correctly Diffused Case.

Applying Welding to the Strengthening and Erection of Steel Structures

Reviewing the progress in welding before the Junior Institution of Engineers recently, Dr. Gardner stated that only the fringe of its possibilities had been touched.

IN the strengthening of bridges, often rendered necessary by increased traffic loads or corrosion, the main advantages of electric welding were: generally a lower cost than alternative methods of reinforcement, avoidance of delay to traffic using the bridge, in most cases underpinning or staging unnecessary, and the existing structure not weakened or disturbed in the initial stages by the replacement of members and rivets.

The plants employed to generate current for the work were usually self-contained petrol-driven units mounted on a wheeled carriage. The negative terminal of the dynamo was connected to the structure, and the positive to the electrode holders through small regulators for varying the current as required, these being generally situated beside the operators.

The application of electric welding to the complete fabrication and erection of large steel structures opened a wide field; the most notable application to ship construction was the all-welded motor vessel, *Fullagar*, built in 1920 by Messrs. Cammell Laird and Co., having a gross tonnage of 398 tons and a length of 150 ft. This vessel had passed through very strenuous coastal service, carrying steel plates, rails, and coals, during which she had been aground on many occasions through heavy weather, the severe strains thereby imposed on her steel plating not causing any leakage. The vessel still retains her A1 classification at Lloyds, and has since sailed across the Atlantic, through the Panama Canal and is now working on the North Pacific coast carrying cement.

Large pipe lines in many parts of the world had been constructed by the process, and examples of one in the British Isles was illustrated. Storage tanks, gas works plant, chimneys, etc., had all been constructed. The first completely welded bridge of any magnitude was constructed at Toronga, Australia, 100 ft. in length, with a clear central span of 50 ft.; this was a foot-bridge constructed upon a 24-in. gas main composed of $\frac{3}{16}$ in. steel plate having butt-welded longitudinal seams, the circumferential joints being socketed and welded. The saddles to support the timber flooring of the bridge and the hand-rails were welded, and the absence of drilling was a great advantage, as eliminating the chance of leakage from the main. Another application was all welded steel masts for electrical cable supports, etc.

Recent progress had been marked by the erection of structures designed from first principles entirely for welding, and in which little or no trace of accepted forms of construction employed in riveted practice could be found. In a theatre recently erected on the Continent the roof trusses were designed as "three-pin arches," and built up entirely of plates and flats; all joints in the flange-plates and webs were butt-welded without cover plates, changes in flange section being effected by varying the width of the plates. The flanges were attached to the webs by light 4 mm. continuous fillet welds. The saving in material as compared with trusses of similar rivet construction was estimated at 23%, and the saving in total cost at 28%.

Common Errors in Steel-Making

By Walter Lister.

Part IV.

THE casting of the ingot is a very important part of melting-shop practice, and is not simply a matter of transferring the steel from the ladle to the mould in the shortest time possible, as many teemers seem to think. There is room for a good deal of intelligence and sound practical knowledge in the casting bay. For instance, the temperature of casting may very often mean hundreds of pounds sterling either lost or gained. And in my experience, a bad teemer can make more scrap than a bad melter.

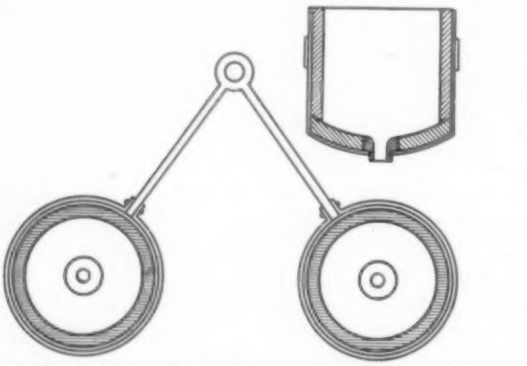


Fig. 1.—Cylindrical Pot or Tun-dish for use when casting on Carriages.

The first thing a teemer should learn should be to judge the temperature of the steel as it is leaving the ladle, or as it is rising in the moulds. The rate of teeming should be regulated accordingly. A heat may leave the furnace abnormally hot, a fact which may not have been communicated to the teemer. With a teemer who specialises in one rate of teeming only for all casts, this will probably be scrap, but a teemer who knows his job will notice at once the absence of "cream" as the ingot rises in the mould and will immediately slow down his rate of teeming. A man who has studied things can always tell fairly accurately by the amount of cream on the surface of the ingot as it rises in the mould, what his rate of teeming should be in order to get the best possible results in the ingot.

A very hot cast will rise without cream, a normal cast will show a thin cream broken up into patches, while a cast on the cold side will rise with a thick cream covering the whole surface of the ingot and offering resistance to the further rising of the steel. This "cream" is due to a slight freezing of the surface on exposure to the air, and has very much the appearance of cream on milk. Alloy steels, of course, especially those containing chromium, show more cream for the same temperature than plain carbon steels, and this fact should always be made use of in casting this class of steel.

In using a series of tun-dishes or troughs, the size of nozzle in the tun-dishes should be increased slightly in each successive dish in order to teem more rapidly as the charge in the ladle cools. For example, with a series of eight tun-dishes, the first two would probably have $\frac{1}{2}$ in. nozzles, the second, $\frac{7}{8}$ in., the third, 1 in., and the last two, $1\frac{1}{8}$ in. This idea should also be carried out when teeming groups. The first half of the cast would probably consist of groups of eight moulds, and the latter half, groups of six, finishing up with a group of four. This arrangement avoids the evil effect of the other extreme, viz., teeming too slowly. The back-end of a cast always comes in for a lot of slander which it doesn't deserve. With careful manipulation in casting, it should be quite as good as the other end.

Slow teeming, when the cast is getting cold, tends to form laps on the surface of the ingot. These result in scrappy bars in the mill. In teeming directly into the mould, care should be taken not to teem so slowly as to splash the sides of the mould. It is bad practice to teem a little, and then stop, and after a few seconds, go on again. Constant opening and shutting of the stopper throws steel on the sides of the moulds. It is much better, if the cast is too hot, to open just sufficiently to get a clear stream and keep it at that until the steel has cooled down to a temperature that will permit of the stopper being opened to its fullest extent.

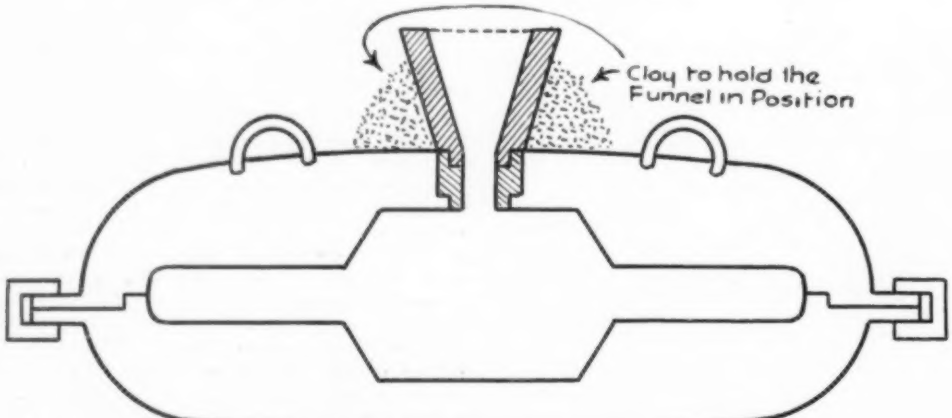


Fig. 2.—Section of Mould for casting Wheel Centres, showing the two segments clamped together and the funnel in position for pouring.

In casting on carriages, swinging tun-dishes or funnels fixed on the columns of the casting stand, are very useful for avoiding too hot a casting temperature. As seen in the illustration (Fig. 1), this consists of a cylindrical cast-iron body into which is fitted a brick lining with a brick saucer-shaped bottom and nozzle. A holder is made to

fix on to and swing on the columns of the casting platform, and carries two pots, which are held in the ring of the holder. As the moulds are brought under the ladle, the holder is swung so that one pot is directly over one of the moulds. The other holder (supposing a two-stoppered ladle is in use) is fixed to engage the other mould on the same carriage. Normally, two pots will be sufficient through which to teem a 60-ton charge, but if for any reason one is put out of action, the other can be brought into use by simply swinging it into position. When used, the pots can be lifted out of the holders and new ones inserted ready for the next charge.

When the temperature of the cast has fallen sufficiently, the tun-dishes can be discarded and the operation finished by direct teeming. There is no need to take the tun-dishes off; merely push them aside, and the steel falls directly into the moulds.

The same idea can also be used for pit casting over stationary moulds, but this has the disadvantage that when the tun-dishes are not required the ladle cannot be lowered nearer the moulds, as can be done on a casting stand fitted with movable ladle holders, owing to the fact that the dishes have got to be fixed on the bottom of the ladle itself. In teeming large ingots for forging purposes, the question of temperature is still more important. With nickel steels, for instance, rapid teeming at a temperature above 1475° C. is almost always fatal, the ingots developing surface cracks immediately after casting. The teemer should carefully watch the cream. Nickel steels should always carry a medium to full cream to ensure the best results.

I append a few typical examples of teeming large ingots in the hope that they may be of some practical use.

Weight of Ingot.	Temp. as Cast.	Size of Nozzle.	Time Teeming.		Remarks.
			Ingot.	Head.	
Tons.		Mms.	Mins.	Mins.	
9	Cold	35	4½	3½	Carbon steel. Thick cream. Stopper full open. Skull in ladle.
9	Very hot	35	10	6	Carbon steel. Stood 4 mins. before opening stopper. Half stopper for 5 mins., then ¾ to finish. Light cream. Ladle clean.
1 ÷ 8 1 ÷ 3	Normal	35	4¼ 2¾	4 2	(1) Carbon steel. Waited 2 mins. Half stopper for 1 min., then full. Half open for head. (2) Half open for 40 secs., then full. Half open for head. Ladle clean.
28	Norm'l	35	14	9	Carbon steel. Half stopper for 1 min., then full. Half open for head. Ladle clean.
22	Norm'l to hot	35	12½	6	Nickel. Half for 40 secs., then full. Half for head. Medium cream. Thin skull.
8	Hot to very	30	8	5	Nickel. Half for 40 secs., then full. Half for head. Very light cream. Ladle clean.
8	Hot	30	5½	3¼	*Ni., Cr., Mo.:* C.C., 0·28; Cr., 0·79; Ni., 2·5; Mo., 0·50. Half for 25 secs., then full. Half for head. Cream medium to full.

It will be noticed that in filling the head, the rate of teeming is very slow, the stopper being only half open, or less. This is necessary in order to ensure that there will be no pipe in the body of the ingot. This remark also applies to smaller ingots cast for the rolling mill.

It is very necessary that a complete record, something on the lines I have indicated, should be kept of every cast, so that the conditions of teeming, etc., can be referred to if any complaints arise. It is only in this way that trouble can be avoided and a satisfactory practice built up. I am afraid that many works are very careless in this respect. To further ensure sound ingots, all dead steel should have the tops kept liquid as long as possible. A shovelful of fine producer ash should be thrown on immediately casting is finished, and on top of this a layer of charcoal in small pieces. This should be done in all cases, large ingots or small ones, and whether the ingots have feeder heads or not. In group casting, about three tons per minute can be safely teemed, slowing down a little on the steel approaching the top of the moulds. In casting on carriages directly into the moulds, two tons per minute is sufficient at normal temperatures.

A lot of steel is made to-day of the rimmed-in variety, or in other words, with "cauliflower tops." This steel is usually dead soft, and rises in the moulds due to evolution of gases. There is an unsightly mess at the top, to say nothing of a wonderful collection of blow-holes inside. Steel in this condition can only be used for very inferior classes of wire, etc., and for rods for reinforced concrete. It is best buried out of sight. Still it could be made more presentable if it was cast in inverted moulds with lids on. It would rise as far as the lid, and then solidify with a nice flat top. Failing the lid, a piece of scrap plate placed on the top would prevent the "rise" developing into an upheaval. Also, an ingot with a top under some sort of control will allow of even less discard than one of the "cauliflower" variety.

Casting Wagon Wheel Centres.

As solid-centre wheels for railway wagons are now rapidly displacing spoked wheels, the casting of the centre can be made a very profitable side-line in an Open-Hearth plant. The most convenient type of furnace for this class of work is a small basic furnace of about 25 tons capacity. As no satisfactory method of group casting has as yet been evolved, each mould has to be filled separately,

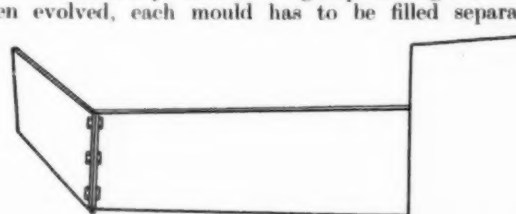


Fig. 3.—Sketch of Lander, with removable end or "bonnet" for preventing the flow of steel from hitting the side of the ladle.

direct from the nozzle of the ladle. The moulds are of cast iron, and are made in two sections, as shown in the illustration. A short fire-clay sleeve is fitted in the centre, on to which is fixed a fire-clay funnel for pouring and to form a sink-head. With a single-stoppered ladle held in slings by an overhead crane, 45 to 50 moulds can be filled before the steel becomes too cold to run. As each wheel-centre will weigh about 6 cwt., this number will require about 15 tons of steel. This means that, with a 25-ton charge, 10 tons will be cast into ingots, and the remainder run into wheel-centres.

As the carbon specification is .12 to .18%, the ingots will come in for almost any class of mild steel. The best method of casting is to lay the moulds on the floor of the casting bay in, say, three rows, with 15 to 17 moulds in each row. They should be placed in perfect alignment, so that it will be easy for the crane to pass from one to the other with a minimum loss of time. The crane driver soon becomes expert in judging the distance between each mould as the space between the centres of each is always exactly the same.

As soon as the required amount of ingots are cast, the ladle is immediately carried to the wheel-centres. A nozzle of about 45 mm. dia. is the best to use as this allows for

rapid pouring with less danger of freezing up. As each mould is filled, the head is covered with a layer of powdered charcoal. This keeps the head liquid long enough to feed the centre of the casting. After five or six moulds have been filled, the men commence to knock the heads off. By the time the last mould has been filled, stripping can commence, and in about half an hour after casting the whole of the centres will have been stripped. The total time occupied in casting ingots and centres will have been about 35 minutes. A two-stoppered ladle can be used, but in this case it is better to cast in a pit with a ladle running on rails above the moulds. Great care should be taken to see that the centres of the moulds are in alignment with the nozzles, or a nasty mess will result. Of course, with a two-stoppered ladle, a double quantity of centres can be cast in the same time.

If the nozzle freezes up before the ladle is empty, it can easily be made to run again by burning out with oxygen. The only apparatus necessary is a length (about 10 ft.) of ¾ in. gaspipe, and a cylinder of oxygen. About two feet of the pipe is bent at right angles in order to enter the nozzle. The other end is attached by means of a strong rubber tube to the cylinder of oxygen. As soon as the steel shows signs of freezing up, the bent end of the pipe is inserted in the nozzle, and the oxygen turned on. The solidified steel can be burnt through in a few seconds, after which the remaining centres can be run.

It is never advisable to try to teem more than 45 to 50 centres through a single nozzle as, owing to the last portion of the charge being so long in contact with a comparatively large body of slag, any centres cast over this number will probably become gaseous and rise in the head, developing a honeycombed structure. Any centres which show this tendency should be rejected. At the wagon works, the castings are pressed into shape and the solid hub punched out. This eliminates any piping there may have been in the centre as cast.

One 25-ton furnace can make about 700 centres per week, and with care, there should be less than 1% of rejections. Besides wheel-centres, various other small jobs can also be profitably undertaken, such as casting tyre lumps, billet-size ingots for rod rolling and slab ingots for sheets.

The Casting Ladle.

In all modern steelworks, laid out on mass production lines, all the ladles in use should be of unifrom size and shape, but in many shops, especially the older plants where the furnaces vary in capacity, the ladles also vary accordingly. But whatever size or shape the ladle may be, a lot of care is necessary in order to get as long a life as possible out of the brick lining. And I am afraid that this is a matter considered of little importance in some works, even with the heavy costs of to-day.

In setting the ladle under the lander, for instance, a lot of damage can be done by the flow of steel impinging on the far side, and cutting a channel in the brickwork. This is more in evidence when there is a large tap-hole, but it can always be avoided by moving the ladle farther back on the stand. If the ladle is being held in slings by the crane during tapping, of course, it is then quite easy to adjust it to the flow of steel, but I do not recommend this practice, as it causes too much idle time for the crane, except in the case of tilting furnaces, and, even then, the lander can be so arranged as to be able to tap into a ladle on a stand. But a simple device can be fixed on the end of any lander which will avoid any possibility of damage to the ladle. This is shown in the illustration (Fig. 3), and consists of a short piece set at a greater inclination than the main protion of the lander. This causes the flow of steel to fall more directly into the ladle, and so avoid striking the side.

Another way in which a lot of damage is done to the ladle lining, and the life consequently shortened, is the practice in many works of throwing water into the hot ladle. This should never be allowed, as it causes more corrosion of the brickwork than many charges of steel. Of course, it is done with the object of cooling the ladle down quickly in order to be able to get inside and ram another nozzle ready for the next charge. But this is not necessary, as new nozzles can be put in without the necessity of getting inside the ladle at all. The method is quite simple. First of all, the ladle is fitted with a loose nozzle-box, which is fastened to the bottom by means of cotter pins. After casting, the ladle is tilted in the trunnions on the carriage or stand, so as to bring the nozzle-box or boxes into a convenient position for removal. The cotter pins holding the box are then knocked out, and the box (containing some of the old nozzle-pot) is taken off. The tapping hole is now exposed, and it is an easy matter to clean out the remainder of the old nozzle-pot by means of short bars. In the meantime, a new nozzle-pot has been rammed into a spare box. This is well daubed over with ganister or good refractory fire-clay, and inserted in the tapping hole. The ganister or fire-clay should fill up any space between the walls or sides of the tapping hole, and make a tight joint. The cotter pins are then inserted in the bolts, and the whole well tightened up. It only remains now to finish off from inside the ladle. This is done by lowering the ladle bottom a little, and throwing a ball of wet ganister into the tapping hole, so that the orifice is entirely filled. A long bar with a loop on the end is then employed to work the ganister into the sides of the tapping hole clear of the nozzle pot. Any surplus ganister in the nozzle is easily cleaned out afterwards by means of a long wooden pole pointed at the end. The initial heat of the ladle is often sufficient to dry the nozzle, but, if not, only a short time under the gas is necessary.

The stoppers can be fixed immediately after the nozzle has been replaced, but while drying under the gas they should be screwed up clear of the nozzle brick. By this method of changing the nozzle, a ladle can be got ready for another cast in about one and a half hours, and two ladles in commission will be sufficient for five furnaces instead of one ladle per furnace as is usually the case when stoppers are set from inside the ladle.

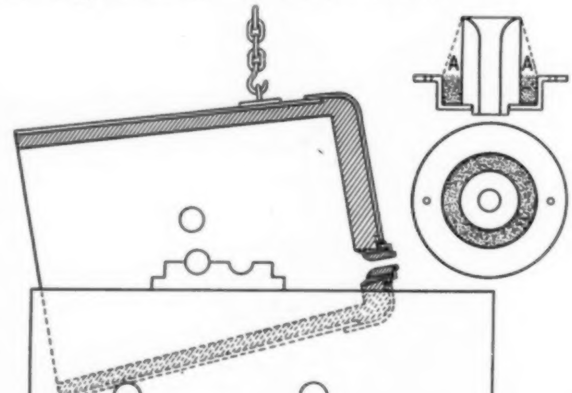


Fig. 4.—Ladle in position on the carriage forchanging the nozzle pot. The nozzle casting is shown in plan, and section with the nozzle fixed. At the point A the nozzle brick is well daubed over with fireclay before inserting.

The Nozzle Brick.

The question of the composition of the nozzle brick is very important. Some fire-clay nozzles burn completely out before half the charge is teemed, while others split in use. Graphite nozzles are satisfactory in everything except cost. They are far too expensive for ordinary purposes. Magnesite nozzles will not stand up to the work ; they crumble on contact with the heat. In my experience, the most satisfactory nozzle brick is one with a magnesite " inset " in a fire-clay body. This gives the refractoriness of the

(*Continued on page* 214.)

Principles and Uses of Wire Rope

Part V.

By WALTER A. SCOBLE, D.Sc., M.I.Mech.E.

Head of Engineering Department, Woolwich Polytechnic.

WHILST ropes which consist of one layer of strands laid on a central core are being dealt with, it is appropriate to note that certain additional features have been introduced into the construction from time to time, none of which have secured a wide measure of acceptance. Only one such specialty will be described here—namely, a core formation which is due to Mr. Westgarth. Apparently, he realised that strands bed into the fibre core, and that if the core be small, then the strands press heavily on each other, and there is a cutting or nicking action when they move relatively to each other by bending of the rope. It follows that a rope core should not only support the strands, but in doing so should prevent undue pressure between adjacent strands. Westgarth's method for effecting this is shown by Fig. 1, specially shaped ribbon being laid round the fibre core with a pitch equal to that of the strands. It is said that the ribbons first used were quickly cut into strips, but that this difficulty has been overcome.

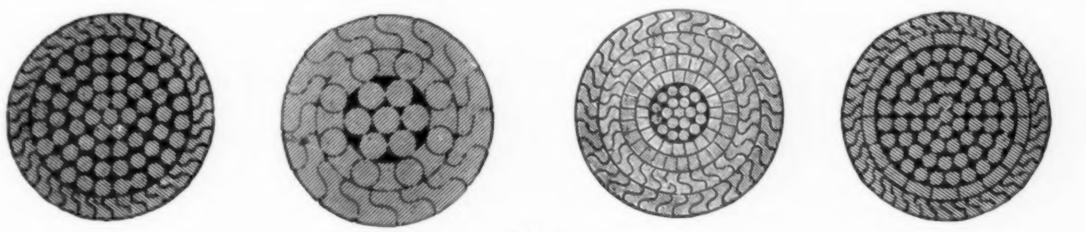


Fig. 1.

It seems probable that the ribbons may not take up or retain the positions shown in the diagram, when the designed support for the strands may not be afforded, and, further, the sharp edges of the ribbons may cut into the wires. At the best, the wires have not the soft, resilient bedding which is given by fibre, and wear between the outer wires and the strip must occur.

Locked Coil Ropes.

There is another important class of ropes which is described as "Locked Coil." It would break the sequence of the present treatment to deal fully at this stage with the advantages claimed for these ropes, but reference to Fig. 2 shows that they have a smooth, round periphery. Locked coil gives the maximum strength for the diameter, because there is no waste space in the section, and each wire is set at a uniform pitch, whereas in stranded ropes the angle between a wire and the axis of the rope varies from point to point. Fig. 3 is a photograph of a single, pre-formed wire in the position which it takes in an ordinary lay rope, and it is evident that, whereas the inclination of an outer wire to the axis of the strand almost balances the slope of the strand in the rope, and gives an outer wire nearly an axial direction at the outside of the rope, at the inside of the strand, next the core, the inclinations add and a wire makes a large angle with the rope axis.

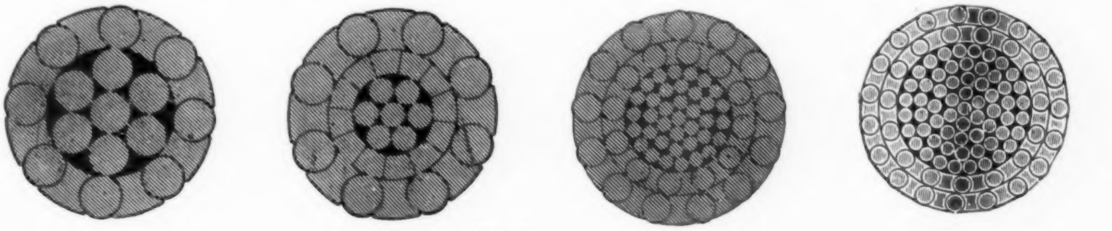


Fig. 2.

In Fig. 2 the ropes are divided into "half-locked" and "full-locked," as made by Messrs. J. and E. Wright, of Birmingham, and it is clear that the composition of such a rope can be varied in many ways, notably to make it more flexible if it has to be bent by passing over pulleys and drums.

Trulay Ropes.

A new principle in rope construction was introduced into Britain a few years ago by Bruntons of Musselburgh, manufacturing under licence from the American holders of the patent rights. The method is denoted by the name "Trulay," and British ropes now have a similar product with one strand coloured blue.

The strands and wires of an ordinary rope have to be held in position at their ends by serving the ropes with wire, cord, spun yarn, or the like. The wires and strands are given certain forms during the laying-up of a rope, part of the deformation being elastic and part permanent set, the yield stress of the steel being exceeded. We may consider that the wires are partly set and partly sprung into position, and the latter makes it necessary to hold the strands in place, otherwise they spring apart, but the fact that the wires are bent proves that they have taken a permanent set. Fig. 4 illustrates the opening up of a wire rope and the permanent set of its wires. Before a wire rope is cut it must be served on either side of the proposed cut, because, unless this precaution be taken the rope will unlay by the strands untwisting and coming apart.

By the Trulay method of construction the strands and wires are pre-formed and set into the exact shapes which they take in the rope, consequently there is no tendency for a strand to spring out of position, and no serving is required (Fig. 5). A strand can be taken out of a rope and replaced without difficulty. Pre-forming has many points in its favour, which will be noticed when the properties of ropes are discussed. The principle of setting the strands

in position seems to offer the possibility of further developments which may lead to the improvement of ropes.

The Length of Lay.

The length of lay corresponds to the pitch of a thread, being the length, measured parallel to the axis, in which the wire or strand makes a complete turn about the axis

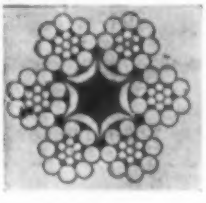


Fig. 3.

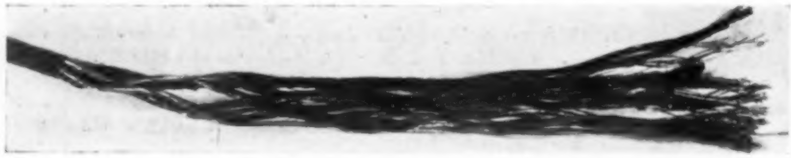


Fig. 4.

of the strand or rope respectively. This is illustrated in Fig. 6 by taking a strand out of a Trulay rope, but the lay of a wire should be measured when the strand is straightened.

The length of lay of ropes is usually left to the manufacturer, which he prefers, because the engineer does not trouble to study the question, or he will not take the responsibility of stating the lay he desires. British specifications do not refer to the length of lay, and the only

Fig. 5.

Fig. 6.

reference to it in a specification for general use, which is recalled at the moment, appears in the American Petroleum Institute Wire Rope Specification, which limits the lay of the strand to $7\frac{1}{2}$ or 8 times the nominal rope diameter, according to the flexibility of the rope. The lengths of the lays of the wires and strands are extremely important, and do not receive the attention from engineers which they deserve. All the effects of the length of lay cannot be dealt with until the special properties of ropes are discussed, but a preliminary treatment of lay is undertaken here.

When wires are laid in a strand the strength of the strand is less than the sum of the strengths of the separate wires. To make this clear a 19-wire strand, 12 on 6 on 1, will be considered, after which it should not be difficult to modify the treatment to suit other constructions. The central wire is straight in the strand and develops its full strength, which may be taken as $f\ a_o$, f being the tensile strength of the wire, and a_o its sectional area. The next layer consists of six wires, which are laid at an angle θ to the core wire and axis of the strand (Fig. 7). Each wire can exert a pull $f a$, a being its sectional area, in the direction of the wire, which can be resolved into $f a \cos\theta$ in the axial direction as the contribution of this wire to the tensile strength of the strand. If the twelve wires in the next layer have an inclination θ_2, but are of the same size, the axial pull of a wire is $f a \cos\theta_2$, and the strength of the complete strand is $f\ (a_o + 6\,a\,\cos\theta_1 + 12\,a\,\cos\theta_2)$, whereas the aggregate strength of the wires is $f\ (a_o + 18a)$.

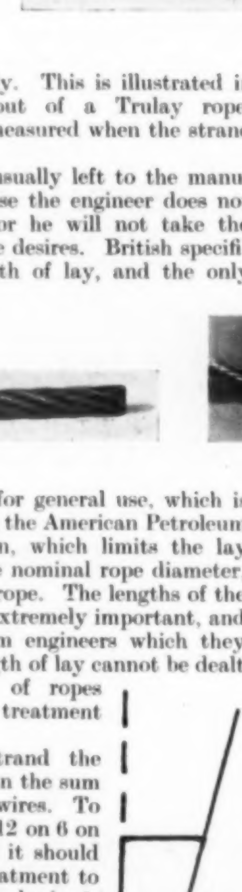


Fig. 7.

The strength of a strand as found above may be represented by S, and the strands are laid at an angle a to the axis of the rope, so the strength of the complete six-stranded rope is $6\ S \cos a$.

The first result given for a strand agrees very well with practice, but that for the rope needs some qualification. It will be shown later that tension on the rope increases the lay of the strands, and the strands close on and compress the core, which allows the strands to press on each other and to indent the outer wires at the points of contact between adjacent strands. The strength of a rope is less than that given by the formula derived above, on account of the lengthened lay and the indentation of and pressure on the wires, the weakening factors being increased when the core is small or soft, and by the use of higher tensile wire. The lays actually adopted, and the strength of ropes, will be understood more clearly from actual numerical examples. The data used below were obtained by careful measurement of existing ropes.

A small 6×7 rope will be considered first, and it will be convenient to record all the dimensions before the analysis is undertaken. The diameter of the core wire is 0·035 in., and of the other wires 0·034 in. The diameter of the strand is 0·105 in., and of the rope 0·327 in. The lays are: Wire in straight strand, 0·99 in.; strand in rope, 2·0 in.

In the first place, it will be noticed that if the outer wires bedded closely on the core-wire, then the strand diameter would be 0·103 in., and the actual value corresponds to a clearance between outer and core wires of a thousandth of an inch. The rope diameter is greater than three times the strand diameter, because the core is made large to relieve the pressure between the strands. It was shown earlier that the core diameter should be larger than that of six wires or strands which touch each other, so the core diameter of this rope has little beyond this to allow for the closing of the strands and crushing of the core under tension.

The angle at which the wires are laid in the straight strand is calculated from the fact that an axial length of 0·99 in. corresponds to a circular path, which may be considered to have a diameter of 0·070 in. The tangent of the angle which a wire makes with the axis is $\pi \times 0{\cdot}070/0{\cdot}99 = 0{\cdot}222$, and the angle is nearly $12\frac{1}{2}°$. Similarly, the angle of the strand is $\tan^{-1} \pi \times 0{\cdot}222/2$, or $19\frac{1}{4}°$. Assuming the wire to have a tensile strength of 80/90 tons per square inch, and working with the mean value 85, the strength of the core wire is 0·0801 ton, and of the other wires 0·0771 tons. The strength of the strand is $0{\cdot}0801 + 6 \times 0{\cdot}0771 \times 0{\cdot}9764 = 0{\cdot}532$ ton, and since the aggregate wire strength is 0·5427 ton, the strand efficiency is approximately 98%. The calculated strength of the complete rope is $6 \times 0{\cdot}532 \times 0{\cdot}9443 = 3{\cdot}03$ tons, and its efficiency is $3{\cdot}03/6 \times 0{\cdot}5427$, or 92·6%, which is in good agreement with the 92% usually applied to this construction.

The next rope considered has 6×19 construction, and is of 2 in. nominal circumference. The actual diameter is

(*Continued on page* 214.)

The Sandberg Sorbitic Steel Process

Physical Variations in steel are fundamentally due to influence of chemical composition and heat-treatment. In this article heat-treatment is considered.

IN the authoritative work "The Microscopic Analysis of Metals," by F. Osmond and J. E. Stead, D.Met., F.R.S., Osmond states: "In my opinion the present methods of manufacture of rails, etc., will appear primitive in the future, and I hope the greater quantity of pearlite in our steel will be replaced in future practice by *Sorbite*."

It may be pointed out that the condition desired by Osmond is not achieved by any addition to or variation of the chemical contents of the steel. In the Sandberg process, the sorbitic condition or structure is obtained solely by means of the regulation of the rate of cooling through the critical range of temperature, which has great influence on the resulting structure of all qualities of carbon and alloy steels.

Rail Treatment Plant.

In the James Forrest lecture "Some Recent Services of Metallurgy to Engineering," delivered by Prof. Sir H. C. H. Carpenter, Ph.D., F.R.S., at the Institution of Civil Engineers, Professor Carpenter made the following observations:—Stead and Richards concluded that if Sorbite is responsible for the excellent qualities of oil-quenched steel and negatively quenched steel wire rods, there is no reason why it should not be produced in steel rails, tyres, etc., without great expense. With this object in view, they experimented on 5-ft. lengths, subjecting them to a variety of treatment.

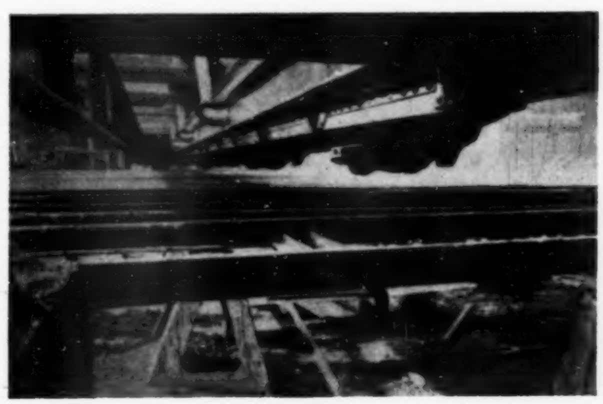
Their work showed that the maximum quantity of Sorbite could only be obtained by rapid cooling to below the critical points, followed by tempering. They showed photographs indicating the difference between sorbitic and ordinary steel. The micro-structure of the sorbitic and pearlitic portions shows a marked difference. The latter is a heterogeneous mixture of ferrite and pearlite, while the sorbitic portion appears almost homogeneous.

Although the results of these experiments were decidedly promising, Stead and Richards were not able satisfactorily to treat a normal 30-ft. length of rail. In all their experiments the distortion of the longer lengths was so considerable that their process never became a commercial success. The practical problem of treating the full lengths satisfactorily was solved by Messrs. Sandberg, so as to produce sorbitic structure.

They realised that the right temper in the rail could be obtained in the course of one single operation if the correct rate of cooling through the critical range of temperature was secured. The precise range depends upon the composition of the steel. Their experiments using air cooling were so encouraging that they were soon able to treat full-length rails of heavy section. The results obtained made it perfectly clear also that their process could be carried out without interfering in any way with the output of the rail mills and at a comparatively low expenditure. The first rails treated were tramway rails, and gaugings taken from these after they had been one year in the track under very severe traffic showed that their life would be about 100 per cent. longer than that of the Sandberg high-silicon rails of the same composition, but untreated and laid at the same time in the same track.

Whilst the great physical variations of steel are fundamentally due to the influence of chemical composition and of heat-treatment, in the present instance the question of heat-treatment will be dealt with more particularly.

Rail in Position for Raising.



Rail Raised and in position for Treatment.

There are four distinct types of crystalline structure due to varying degrees of heat-treatment, each possessing its own marked characteristics, which are shown in Table, and Fig. I shows these four types of structure.

The characteristic feature of the Sandberg sorbitic process is that the cooling of the steel is carried out at a

rate which brings about and retains the sorbitic structure in one operation, thus avoiding the distortion which accompanied quenching and obviating the necessity for subsequent tempering. The cooling is performed by

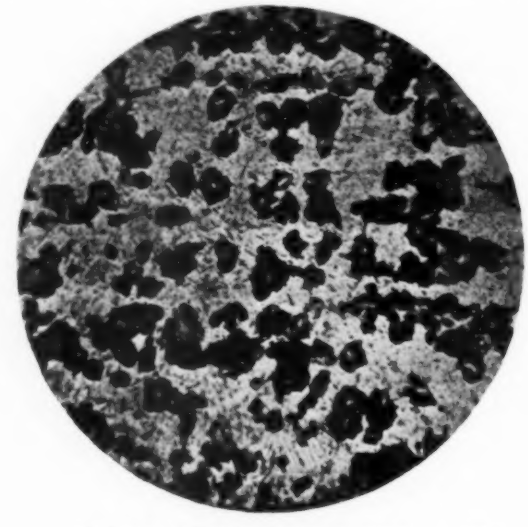
TABLE.

Type of Crystalline Structure.	Obtained by	Physical Characteristics.
1. Martensite....	Quenching	Extreme hardness and brittleness.
2. Troostite	Slightly slower cooling.	Slightly less hard and less brittle.
3. Sorbite (Sandberg process)	Cooling at medium rate.	Maximum combined hardness - toughness.
4. Pearlite	Slow cooling	Maximum combined softness - ductility.

with carbon, and it is the co-operation of the two which leads to getting the best results obtainable from the material dealt with, and gives a good rise in hardness-toughness, combined with wear resistance, where greater hardness through increase of carbon alone might become dangerous. The Sandberg process is applied to rails after they have been "hot sawn" to length and before they have begun to cool through the critical range. When the hot rail leaves the saw it comes to the treatment plant, and automatically its head is brought under a row of close pitched nozzles, through which sprays of "Scotch mist" impinge on it, enveloping the entire head.

The rail-treatment plant consists of a long narrow box or hollow girder capable of dealing with the longest rails in demand. It is connected with an air blower and water supply, and fitted with patent ejector nozzles which mix the air and water and impart an eddy effect to the mixture as it leaves the nozzle. Cooling thus takes place at the

(1) *Martensite.* × 400.



(2) *Troostite* (*dark*) *in Martensite* (*light*). × 250.

(3) *Sorbite.* × 1000.

(4) *Pearlite.* × 1000.

Fig. 1.

blowing air, steam, or moistened air on the hot metal, commencing at a temperature above the higher critical limit and ceasing at a temperature well below the lower limit. As is well known, it is chiefly the carbon in steel which gives it its initial hardness, but it is not always so fully realised that its best qualities can be developed by suitable heat-treatment.

Heat-treatment should be considered in conjunction

rate necessary to give the rail head a sorbitic structure instead of the pearlitic structure, which it would have attained by normal cooling. The tensile strength of rails is thus raised from about 50 tons per sq. in. untreated to 60 and 65 tons per sq. in. after treatment, and even higher, without showing any signs of brittleness. Treated rails have, in fact, stood up to twice and even three times their specified falling weight test without breaking. Brinell

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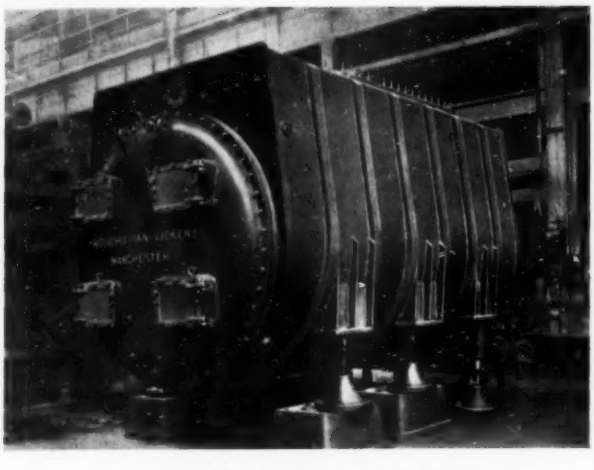


Fig. 1.—Fabricated Condenser Shell.

Welded Structures

Developments in welding processes have resulted in remarkable progress and new applications are continually meeting success.

MODERN welding appliances and processes, together with the practical diligence of the operating welder, have made such remarkable progress that welding has now become a very important industry, but although considerable impetus has been given to this comparatively new industry in displacing riveting and hollow forgings for the manufacture of pressure vessels, particularly in America, its application for such purposes is not regarded with universal approbation. This is probably due to the fact that there is no generally recognised standard for high-class work in this country, and, in consequence, designers have no recognised data upon which to base their calculations for constructions. As might be expected under such circumstances, the results are frequently unsatisfactory. It is, to a large extent, in improvement of design that the future of welded pressure vessels lies, as the defectiveness of design, rather than defective methods of welding, is responsible for the suspicion with which these vessels are viewed.

There is, of course, ample evidence available to show that the welding of pressure vessels is looked upon with disfavour by the responsible government departments, and this disfavour naturally extends to those who are responsible for supervision and have to bear the censure in the event of an accident. It is as well that this conservatism prevails,—that structural changes are gradual; but continued research in perfecting the design of vessels so that the weld is kept away from serious bending stresses, avoiding sudden changes of section and using a welding metal capable of withstanding shock and fatigue, will ultimately remove the difficulties retarding its more rapid development in this direction.

Probably the most notable illustration of the developments in welded structures is that taking place at the present time in the design and manufacture of electrical equipment. The size and variety of work now being accomplished, and the increasing use of welded structures, in work for which iron or steel castings were previously used exclusively, speaks volumes for the progress being made in welding. There is no doubt that for certain designs of structures, for many purposes and in many circumstances, the use of fabricated steel has marked advantages over castings. In the first place, the expense of patterns is totally eliminated, a factor of considerable importance in economical production, and as structures can be given adequate strength and rigidity with considerably less weight, the method saves in material because less is used and less is wasted.

Fabricated structures are free from those defects to which castings are subject. The possibility of blow-holes, shrinkage cavities, or shrinkage strains, which may render a casting useless, is not likely to affect a welded structure. There are also advantages of design and quality. In the first place, comparing a welded steel structure with an iron casting, properly designed the steel structure will be stronger, yet lighter. For equal sections, subject to bending, the welded structure is about three times as strong as cast iron, and about twice as stiff. Further, the design is not limited to existing patterns, modifications can be made to any one design, and the structure can be designed on a basis of strength rather than by consideration of the best proportions for casting. The likelihood of distortion in cooling also imposes limitations on the design of castings, and, incidentally, causes a greater allowance for machining than would otherwise be necessary. It must not be assumed, however, that no distortion is possible in welded structure ; it is necessary to exercise care in designing and in the operation of welding to avoid distortion due to the contraction of the weld in cooling. Welded structures are greatly facilitated by the large variety of steel sections of standard sizes that are available at comparatively low cost, from which it is possible to form almost any desired construction of either stationary or rotating parts of electrical machines, and, with regard to design modifications and developments, the adoption of welding methods gives increased scope by the greater facility it affords of dealing with new or special forms.

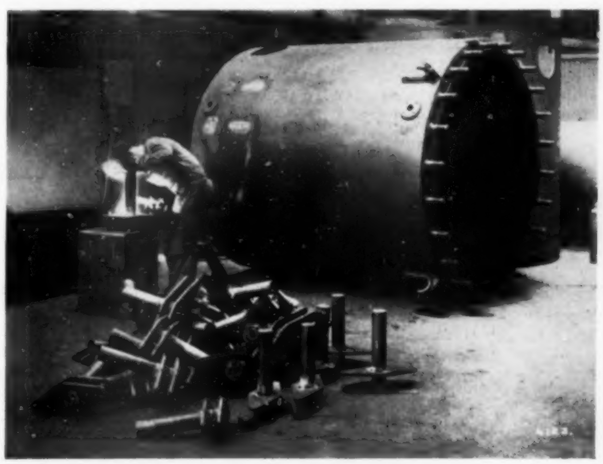


Fig. 4.—Large Circuit-breaker Tank.

In this development all the leading electrical companies are taking a part. Many important applications of welded construction have been developed, which include frames for turbo alternators and other large machines, the shells of steam condensers and evaporators, bedplates and pedestals, together with the frames and castings of a great

variety of other equipment. Metropolitan-Vickers, for instance, have completed a considerable number of large machines with welded stators, including a turbo-alternator of 62,500 k.v.a. capacity, and this company has under construction or on order about twenty machines of over 25,000 k.v.a. capacity with welded stators, the largest being

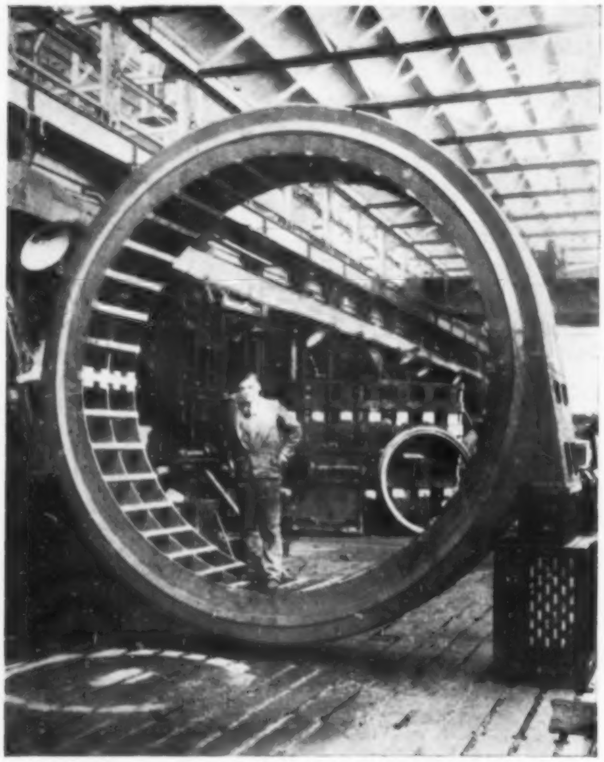


Fig. 2.—Stator Frame for Three-phase Alternator.

one of 80,000 k.v.a. capacity. An example of fabricated structure made by this company is illustrated in Fig. 1. It represents a condenser shell for a 12,500 k.v.a. turbo-alternator set, and consists entirely of mild steel plates welded together to form the structure. The developments in this method have been so considerable that Metropolitan-Vickers have recently made considerable extensions to their works to provide additional accommodation for structural welding. With these extensions the main welding shop is now about 520 ft. long by 80 ft. wide, and is equipped for this kind of work on a large scale. The equipment includes exceptionally large guillotines, bending machines, and punching machines for dealing with the large plates. The welding sets are all of the single-operator type, and mainly of the improved portable type recently developed by the company. The growing importance of welding in various industries is shown by the very large number of sets of this type which are being supplied.

The illustration, Fig. 2, is from a photograph taken at the Stafford works of the English Electric Co., and represents a fabricated stator frame for a 10,000 k.v.a. three-phase alternator for water-turbine drive. The complete set will run at 560 r.p.m., and is for use in New Zealand. Stator frames were the first forms of fabricated structure to be developed for electrical machines. They were naturally made to resemble a casting as closely as possible, and to those accustomed to the rounded shapes of a casting the square corners may not be too pleasing. On the other hand, the clean-cut shape and smooth surface of the steel frame find approval from even the most prejudiced. Several types of frames have been developed for the various machines. The box type, illustrated in Fig. 2, can be built up as a complete unit, then bored, and the core assembled in virtually the same way as for a cast-iron frame. For a machine with a horizontal shaft, the box type consists mainly of two web plates, which form the vertical sides of the frame. These web plates are, in the case of the smaller frames, cut out to the exact size and shape from a rectangular steel plate. On larger frames the plates are built up of segments cut from a rectangular plate and welded together to give the required size and shape. The web plates are spaced apart to suit the core length, and then thick wrapper plates are welded to the periphery of the web plates. On the inside of the web plates heavy rectangular crossbars are welded at intervals, and these form the stiffening ribs. The keys which transmit the torque from the laminations to the frame are held in slots cut in these crossbars. Substantial feet made from rectangular bars are welded to the web plates, and near the top of the frame are welded strong lifting bars. The section of such a frame is very similar to the standard cast-iron frame. The laminations are held in position axially by substantial teeth supports welded to thick steel-plate segments and having bolts in each segment. The box-type frame is very suitable for machines that have to be split on the horizontal or vertical diameter.

The rapid development in the extension of electricity services and the applications of this form of power to industry has been responsible for considerable variation in design and construction, particularly as a result of the policy of electrification adopted by the railways, and also from the progress made with the "grid." In Figs. 3 and 4 are illustrated two of the large circuit-breaker tanks taken from photographs supplied by the English Electric Co., and Messrs. A. Reyrolle and Co., Ltd., respectively. Each is constructed to accommodate one phase of a three-phase 132,000-volt switching unit, for use on the British

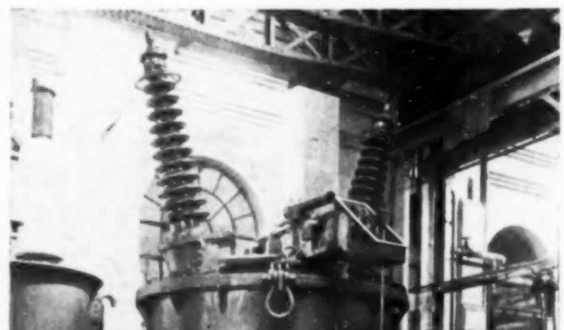


Fig. 3.—Oil Circuit-breaker with Tank.

grid. In Fig. 4, in addition to the main welded structure, several operating cranks are illustrated which form subsidiary welded structures for use on this and similar switches.

A view of a large welded bedplate is illustrated in Fig. 5. This structure measures 14 ft. × 10 ft., and has a weight

(*Continued on page* 213.)

Patenting Wire in Gas Furnaces.

IN the process of the manufacture of rope wire, steel rods are drawn down to wire and afterwards this wire is spun into wire ropes. The wire used varies somewhat in quality, and the terms applied to those more commonly associated with the manufacture of wire rope in this country are referred to in Table I. Some of these are sometimes described by other terms, and one of the commonest is to include the words "crucible cast steel" in the name, similar to that used from the early days in the manufacture of wire rope before the patent process of tempering steel for wire was introduced. The Americans use the term crucible steel wire to indicate a wire up to 90 tons per sq. inch tensile strength. Those having higher breaking strains are termed plough steel wire, reference to the tensile strength of the wire being made in addition to the term.

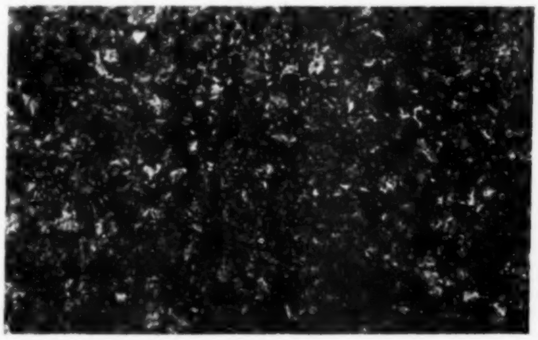


Fig. 1.—Structure of Green Rod Carbon Contents. 0.46% (× 100).

The majority of rope wire is made from Siemens Martin open-hearth steel, the standard being made from basic steel produced by this type of furnace. It can be assumed that at least 60 per cent. of the rope wire produced in this country is of basic quality, the remainder being produced from acid steel. In America and on the Continent of Europe Siemens Martin basic steel is used almost exclusively.

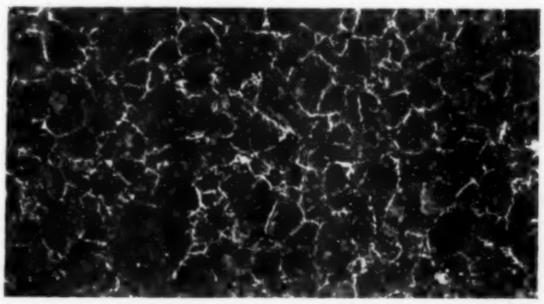


Fig. 2.—Same Rod as in Fig. 1 Patented to 1700° F and Quenched in Molten Salt. × 100.

It is claimed that acid steel has proved itself as giving longer life in the use of wire ropes when the service rendered is severe and long life is desired, and this quality of steel is usually specified when these two factors are required. For ordinary purposes basic steel is used, and when the wire rope is not unduly stressed, and the cost of replacement, inclusive of labour costs in putting a new rope to work, is not excessive, it has generally proved to be the most economical.

From the point of view of the analysis of the steel, the degree of purity of acid and basic steel is about the same, basic steel being, if anything, of greater purity than acid steel. As far as mechanical tests are concerned, neither show outstanding superiority. The limits as to the use of basic steel are governed by the size and the tensile strength, and any wire thicker than 9 S.W.G. is usually of acid steel, and the same applies to wires that have a tensile strength exceeding 110 tons per square inch. While these limits are only approximate, they indicate that the quality of acid steel is demonstrated by its ability to make thicker sizes of wire, and those require l to withstand higher breaking strains, without affecting the durability or mechanical properties of the wire in any way. In the process of manufacture, whether the steel be acid or basic, it is very important that the wire should have certain characteristics as to grain structure, carbon analysis, tensile and bending strength. To meet these particular characteristics, the wire or rods are heat-treated, and this particular treatment is known as patenting.

It is not advisable to do much cold work on the steel rod as received from the rolling-mill, as the steel is in a state of stress and, as regards grain structure, irregular in different parts of its length. The object of patenting is to normalise or regulate the grain structure throughout the rod. The effect is readily seen in the microphotographs in Figs. 1, 2, and 3. In Fig. 1 the structure of a steel rod, having carbon contents 0·46%, is illustrated preparatory to patenting, in Fig. 2 the structure indicates the same rod after patenting to 1,700° F. and quenching in molten salt. Patenting to the same temperature, but quenching in air gives a structure similar to that shown in Fig. 3. To carry out the process of patenting successfully it is necessary to have a correctly designed and heated furnace with which it is possible to ensure regular results with great accuracy.

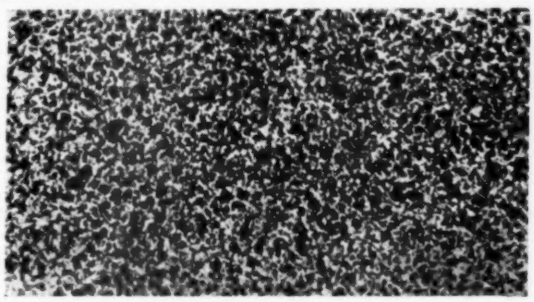


Fig. 3.—The same Rod as Fig. 1, Patented and Quenched in Air. Patented to 1700° F. × 100.

To produce a well-patented rod, it is necessary to heat the steel to sufficient temperature and for a long enough period in order that the carbon in the steel may diffuse throughout the whole of the material. The cooling of the rod must then take place at a speed which will allow the carbon to remain in the correct metallurgical condition, and, at the same time, retain the grain size sufficiently large to produce the necessary fibre size in the finished wire. To produce the desired crystalline structure the speed of the rod in passing through the furnace is determined, after taking into consideration the chemical analysis of the metal, the work already done on the rod, the rate of cooling after patenting, the reduction in size to be effected, and the final strength and toughness desired.

Some small wires are patented two or three times during their passage through the wire mill. The final wire represents a careful balance between crystalline structure and cold drawing stresses, so as to obtain a wire of great toughness (having a high percentage of reduction of area or elongation), yet strong both in tensile and torsional strength. The cooling of the rod, after passing through the patenting furnace is accomplished in two or three ways. The usual

method is to allow it to cool in the air in passing from the furnace to the winding frame.

From the foregoing, it will be obvious that the furnaces used for patenting purposes should be such that the maintenance of the furnace atmosphere and temperature should be under absolute control. When coal, raw producer gas or oil are used as the fuel, it is necessary to use the type of furnace in which muffle tubes are provided for passing

Fig. 5.—Gas-fired Patenting Furnaces.

the wire or rod through, and an inert gas is passed through the tubes with the object of reducing scaling. With the modern clean gas-fired furnace, these tubes are quite unnecessary, because the correct atmosphere can be maintained in the furnace and scaling prevented, or, at least, reduced to a minimum. The elimination of the tubes has the advantage of reducing the cost of the furnaces, and

Fig. 4.—Gas-fired Patenting Furnace, Surface-Combustion Type.

also saves fuel both in the heating up of the furnace and also in the actual heating of the wire, and, by careful grouping of the burners, any desired temperature gradient through the furnace can be obtained, and arrangements readily made for automatic control.

The following is a table of approximate tensile strength in tons :—

	per Sq. In.
Patent steel wire	80— 90
Special improved patent wire	90—100
Best plough wire	100—110
Special improved plough wire	110—120
Extra special improved plough wire	120—130
Galvanised hawser wire	90

A small gas-fired furnace supplied with either town or clean producer gas is an advantage in a wire mill for handling rush orders or special brands of wire, due to its ability to be quickly placed into commission, and also to its extreme flexibility when in operation. Typical illustrations of clean gas-fired patenting furnaces of the "surface combustion" type are shown in Figs. 4 and 5. With regard to gas consumption, an important factor in economical production, an average figure obtained over a long period from an installation of four furnaces was 175 cub. ft. of 500 B.th.u. gas per 100 lb. of wire patented. These furnaces, which are illustrated in Figs. 4 and 5 are supplied by Messrs. British Furnaces, Ltd., of Chesterfield, and are equipped with this firm's well-known "surface combustion" burners.

SIXTH INTERNATIONAL METALLURGICAL CONGRESS.

THE sixth International Congress of Mining, Metallurgy, and Applied Geology will hold its session at Liege during the International Exhibition, to be held on June 22 to 28. The subjects will be considered under various sections and sub-sections, and some idea of the magnitude of the metallurgy section may be gathered from the following list :—

The sub-section on the blast furnace includes raw materials, burdens, yields, and equipment, and in connection with the valuation of by-products the utilisation and elimination of dust and the utilisation of slag.

The manufacture of steel and ferrous alloys forms a comprehensive sub-section in which the problems due to corrosion will be considered, the progress in the casting of steel ingots, and the influence of deoxidisers on their physical condition ; the mechanical properties of rails manufactured by different processes, and the various treatments to which the steel is subjected ; new development in the rolling of sheets and the economic limits of the use of cold rolling.

Problems associated with the foundry form a sub-section, and considerable attention will be focused on non-ferrous metals, and one sub-section covers the influence of the concentration of ores by flotation, on their metallurgical treatment, and also the electrolytic production of metals. In the former the influence on roasting and on reduction will be reviewed, while in the latter the dissolving of metals, purification, and the influence on their purity are to be discussed.

Another sub-section is allocated to non-ferrous alloys, which include special features associated with light alloys, alloys containing cobalt, non-ferrous alloys for cutting tools, and metallic coatings.

The metallurgical section obviously embraces fuels, and the final sub-section includes in its survey the reactivity of fuels, the utilisation of gaseous fuel—with which is associated long-distance transport and the connection between different departments of a works—and thermal control. This is but a brief summary of the subjects indicating the character of the survey within the compass of this section of the Congress.

Institute of Metals Meeting Proceedings Reviewed

By J. S. G. PRIMROSE, A.R.T.C., A.I.M.M.

Considerable attention was directed to improved methods of casting copper and its richer alloys by the elimination of gases.

AT the twenty-second annual meeting of the Institute of Metals, held in London this month, the dozen papers presented maintained the high standard of practical value generally achieved by contributors to the proceedings, and the subject matters dealt with received a good measure of discussion. The consideration of the alloys of brass and bronze was confined to only three of the papers, but chief attention centred round the value of research work on the elimination of gases, chiefly from copper and its richer alloys, in order to attain the greatest degree of soundness in the resulting castings. Other aspects of the papers were historical in regard to uses, academical in considering constitutional changes, and physical as concerning fatigue and protective coatings.

Gases in Copper.

The research work done at Swansea recently has had as its object the elimination of casting troubles to which copper and bronze are subject, due to the separation of dissolved gases during the solidification following upon casting. The three papers presented by Messrs. *Allen, †Prytherch, and ‡Daniels gave full details of their experiments with copper and its tin alloy, and the methods suggested for getting over defects caused by hydrogen and sulphur dioxide gases chiefly. Most of the conclusions have their immediate practical value, and point out that to overcome the blow-holes usually formed by hydrogen in chill-cast copper, either a reduction of the gas pressure in contact with the molten copper to about 6 cm. of mercury, or the passing over the metal for a few minutes of a chemically inert gas like nitrogen or carbon monoxide. In the absence of oxygen, either of these methods has the effect of rendering the cast metal perfectly sound. It was also found that the presence or arsenic or phosphorus in the metal tends to reduce the volume of blow-holes, and may completely prevent their occurence if the quantity of hydrogen present is not excessive. They do not render the copper incapable of dissolving hydrogen, nor does phosphorus effect the removal of hydrogen by combining with it. When oxygen is present, the unsoundness of the cast copper is of a different type, in which the blow-holes are small, more numerous, and tend to congregate at the crystal boundaries. The oxygen exists in the metal as cuprous oxide, and this reacts with the hydrogen present in the copper during the freezing of the metal, and unsoundness results from the steam so formed. Although the quantity of hydrogen present in molten copper diminishes as that of oxygen increases, the removal of the last traces of hydrogen is very difficult, and the action of deoxidants in making copper ingots sound consists in combining with the oxygen present to form an oxide incapable of being reduced by hydrogen. Whilst the work of Allen was on electric furnace melts, that of Prytherch dealt with crucible melting only, and his evidence confirmed the practical observation that when the heating was performed in such a way that gases containing sulphur dioxide and hydrogen were prevented from coming in direct contact with the molten metal, the copper could be cast with much greater soundness and higher density.

Dealing with gunmetal bronze, Daniels confirmed former observers' findings with regard to the relationship between casting temperature and unsoundness. Whilst nitrogen, carbon dioxide, and carbon monoxide have been found to be neutral towards bronze, hydrogen is capable of causing unsoundness in bronze at certain rates of solidification, and this unsoundness can be suppressed by treatment with neutral gases. The usual unsoundness in cast bronze was attributed to the combined presence of hydrogen and oxygen in the melt, as it differs from that produced by hydrogen alone. Improvement in the density of sand-castings can be obtained by melting in a pot-furnace with a thin fuel bed and good draught, compared with melting with a very thick fuel bed and poor draught. Pre-solidification of the gunmetal gave negative results as far as improvement in density was concerned, but this double melting method was quoted as increasing the strength of the cast metal.

Taking the case of casting brass strip-bars in 70/30 and 60/40 composition, Genders described the "Effect of Turbulence due to Gases" on the microstructure of the cast alloys. During the casting of an ingot in the chill mould the dressing progressively volatilises as the level of the liquid metal rises, and the escaping gas produces agitation of the metal. In the lower portion of the mould the gases escape in such a way as to allow the solidification to produce columnar crystals, but in the upper portion of the ingot the evolution of gases continues to produce turbulence until solidification has commenced, and thus the structure is finely equiaxed, and contraction cavities may be dispersed through a relatively wide area. Since this effect is largely dependent on the time required for the volatilisation of the dressing, its influence on the structure will vary with the relation of the period of volatilisation, and the time taken by the ingot section to cool to the freezing point of the alloy. The effect is thus governed by the properties, and amount of the mould coating used, and by such factors as casting temperature, rate of pouring, and size of ingot section. Increase in either of these factors, particularly in size of ingot section, will act in the direction of reducing the effects due to the volatile mould coating.

Phosphorus in Copper.

Continuing the investigation of the effect of impurities in copper, Dr. Hanson, in collaboration with Archbutt and Ford, has completed an extensive research on the "Effect of Phosphorus on Copper." In all, a series of eleven alloys was made containing up to 1% of phosphorus, and the test billets were cast in graphite moulds pre-heated to 350° C., the pouring temperature being regulated to 1,180° C. The ingots were slightly unsound, with very low phosphorus content, but a gradual increase in density was observed, the 0·04% castings closely approaching the density of rolled rod. With over ½% phosphorus, the ingots appeared to be less sound, although the hardness had increased. With up to 1% phosphorus, the alloys stood hot-rolling satisfactorily, and after annealing could be cold-rolled. The limit for cold-rolling of the cast ingots was found to be from 0·79 to 0·95% phosphorus, and the density of rolled rods gradually decreased with increased phosphorus content. Phosphorus additions were found to raise the tensile strength of rolled copper, both at normal temperature and at 250° C. to an extent generally greater than that produced by other elements, such as oxygen and arsenic. The effect is obtained without any marked

* "Experiments on the Influence of Gases on the Soundness of Copper Ingots".
† "Gases in Copper and Their Removal."
‡ "Unsoundness in Bronze Castings."

decrease in the ductility. Although phosphorus and oxygen can be present together in copper, small amounts of phosphorus produce the soundness of the cast billets by removing oxides which results in improved cold-working properties, and in a pronounced raising of the fatigue limit of copper. Impact toughness is not impaired by phosphorus, but the electrical conductivity is lowered very rapidly. The addition of this element raises the temperature at which cold-worked copper is softened by annealing. In all the alloys as cast, particles of copper phosphide are visible under the microscope. After hot rolling, alloys with up to ¼% phosphorus appeared homogeneous, but at ½% some scattered particles of phosphide appeared. With 1% of phosphorus the greater part of the phosphide also appeared to be in solution. The solubility of phosphorus in solid copper increases with rise of temperature from close on ½% at 282° C. to approximately 1% at 682° C. Slight age-hardening of the richer phosphorus alloy occurs in the quenched metal on tempering between 400° and 450° C., subsequent to annealing and quenching from 690° C. The Brinell hardness of 1% strip was raised from 43 to 53, but no corresponding increase in the tensile strength was obtained.

Aluminium Brasses.

New work on this subject by Genders has shown that the influence of aluminium in the ductile brasses is to improve their resistance to corrosion and to oxidation at high temperatures. The alloys containing about 2% of aluminium with 74 to 76% of copper have extremely high ductility, and the cold-rolling properties are not seriously impaired. At high temperatures the workability of the brasses containing 2 and 4% of aluminium is slightly less than pure brass, but with increase of temperature about 500° C. they become rapidly more plastic. The difficulty of taking full advantage of the properties conferred on brass by aluminium lies in the casting process. By adopting the suggestions of melting and pouring used by the author, and now in practical use, the difficulties have been overcome. While 0·1% of aluminium produces a definite increase in resistance to oxidation of brass at high temperatures, 2% is necessary to give high immunity during the annealing process commonly employed in brass strip-making. The pickling defect known as "red-stain," is entirely avoided by the use of 1% of aluminium in brass, and with the higher proportions the need for pickling is removed. The resistance to oxidation conferred by aluminium is as effective in the liquid as in the solid state. It is also shown that the loss of zinc during the melting of aluminium-brass is considerably less than in brass free from aluminium. Repeated re-melting of aluminium-brass has no influence on the mechanical properties of the material.

Protective Coatings.

Mr. L. Davies presented investigations carried out on the "Protective Value of Some Electro-deposited Coatings," in which specimens of steel, brass, bronze, and copper were plated with various thicknesses of cadmium, zinc, nickel, and chromium prior to being subjected to accelerated corrosion tests. On the non-ferrous basis metals, deposits of zinc or cadmium afforded little protection to corrosion in either salt or sulphuric acid sprays, whereas both nickel and chromium acted well. On steel it was found that the types of protection given by cadmium and zinc were essentially different from that of nickel and chromium. Cadmium gave better protection than the same thickness of zinc coating under sulphuric acid spray, but the case was reversed when exposed to salt spray. All thicknesses of chromium were found to be useless for protecting steel in either spray. The protective value of nickel was best; and greater than if the degree of protection were proportional to the thickness of the deposit. Two-thousandths of an inch was the least value from which any permanent degree of protection can be expected from nickel.

Fatigue in Lead.

Dr. B. P. Haigh and Mr. Jones discussed their research on "Atmospheric Action in Relation to Fatigue in Lead," and they conclude that the action is one produced by both chemical and mechanical effects working together. The failure of lead by fatigue is shown to be greatly delayed by surrounding the fatigue test-piece by an oil-bath, or even a water-bath. A thin layer of grease delays fatigue considerably, but, most remarkable of all, a bath of acetic acid eliminates fatigue, whereas a thin film of the same acid does not do so. From this it is inferred that oxygen diffuses through the metal during a fatigue test in air, passing through the marginal zone and reaching a depth at which the fatigue crack shows the characteristic form and discolouration. The reductions in fatigue strength often found when water or chemicals act on the surface of fatigue test-pieces are attributed only in a small degree to the surface actions, such as corrosion or notching, and chiefly to diffusion into the metal of foreign substances that provoke chemical or physical change under the cyclic stress.

Constitutional Changes.

Dr. C. F. Elam described some of her recent experiments with the object of seeing "The Diffusion of Zinc in Copper Crystals." This was found to take place only to a limited extent at high temperatures, around 450° C. The method adopted was also applied to brass crystals of different compositions, and it was found that in a beta brass crystal which was heated in zinc vapour a layer of epsilon constituent was deposited which was also a crystal. The relationship between the two crystals was found to be sometimes parallel growth and sometimes a twin. The diffusion of zinc out of a brass crystal was also studied under vacuum conditions, and the zinc only began to be given off at 550° C.

Dr. D. Stockdale described a very sensitive new apparatus he uses for taking cooling curves in order to determine "The Composition of Eutectics." The systems he attacked were Al-Cu, Sb-Ag, Cd-Sn, Cd-Zn, Cu-Ag, and Pb-Sn, in the endeavour to show that in a binary eutectic the atoms of the two elements present are in a simple ratio.

The Early Use of Metals.

Dr. T. A. Rickard surveyed the early history of non-ferrous metals. He divided the industrial history of mankind into two major epochs—a stone age and a metal age. Between these two there was a transition period, when metals found in their native state were employed, although they had not been extracted from their ores. The melting of copper probably preceded its extraction from minerals by some centuries, and the production of bronze or hardened copper was a later stage in metal culture. The critical event in production of metals by man was the first melting of copper out of "stone," about 3,500 B.C. Metal articles made at earlier periods were fashioned from native gold, silver, copper, or even from meteoric iron. An extensive bibliography was given containing much historical and other evidence in support of the views of the author.

GEOLOGICAL DISCOVERIES.

The Government of Northern Ireland has granted a civil pension to Mr. Robert Bell, a riveter, who has worked for 40 years in the shipyard of Harland and Wolff, Belfast, and has at the same time won a world-wide reputation as a geologist. A recent discovery by Mr. Bell was of two new minerals embedded in chalk at Scot Hill, Larne, which in honour of the locality, were named Larnite and Scotite. After being analysed at Cambridge they were the subject of a paper read by Dr. Tilley, of Cambridge University. Mr. Bell has a remarkable collection of zeolites from the basalts of Antrim and Derry, and specimens of these presented by him have been displayed in the British Museum. He also made valuable gifts to the Belfast Museum, the Queen's University, Belfast, and the universities of Cambridge, Bristol, and Manchester. At his home in Newington-avenue, Belfast, Mr. Bell has a remarkable private collection of minerals.

Review of Current Literature.

PRIOR to the introduction of micro-photography, the metallurgist had little to guide him in the many forms of heat-treatment to which metals are subjected. He only knew that when certain operations in heating, cooling, and re-heating were carried out on a definite predetermined basis, a certain hardening and toughening resulted, but he did not actually know what was taking place in the crystalline structure of the material. Great strides have, however, been made during recent years in the microscopic analysis of metals, and in regard to steel in particular, the peculiar grains or crystals of the metal due to heat-treatment, carbon content, and alloying elements present, have been so far investigated that it is possible by this form of analysis to determine the properties of the steel in its resultant condition.

An immense mass of data has been rendered available on the subject since Sorby made his valuable contributions to the Iron and Steel Institute. To-day the microscopic study of steel is firmly established as a part of the routine work in the works laboratory. Methods of testing have been devised and developed that cover actual service conditions, and photomicrographs have now a very appreciable value in assisting the work of the laboratory in the deductions arrived at from an examination of materials, and to the steel industry they have become indispensable.

In heat-treating of steels considerable emphasis is generally applied to temperature control, though, actually, the time and rate of heating is of equal importance, affecting, as it does, the uniformity with which the product is heated or cooled. The influence of variable section, shape, or surface exposed upon the rate of heating or cooling may involve slow heating or pre-heating in order that the mass may be well saturated before it is subjected to the final temperature, and the converse is true in cooling. The conditions that are applicable in producing certain results in one form of product would be totally unsuited for another form of product from similar material, and this must be kept in mind, because of the great variety and character of products subjected to the action of heat in the process of production.

Iron and steel are complex materials, and owing to the numerous variations in structure resulting from different treatments, as well as varying chemical compositions, a selection of microphotographs prepared from specimens of known composition and treated with accuracy can be used as a basis for comparison. It is in this direction that Mr. Reed has prepared the studies contained in his book. The heat-treatments applied are in a general sense those that have been recommended by the Society of Automobile Engineers, and it is the author's hope that the micrographs will prove of assistance to those engaged in the production, treatment, and uses of iron and steel. The work is well prepared and produced, and it should prove a useful work of reference to all interested in the micro-structures of iron and steel.

By Everett L. Reed, S.B. Published by John Wiley and Sons, New York, and Chapman and Hall, Ltd., London. Price 20s. net.

BOOKS RECEIVED.

"An Outline of Metallurgical Practice." By Carle R. Hayward. Published by the Library Press, Ltd., 83, Southwark Street, London, S.E. 1. Price, 30s. net.

"Melting Iron in the Cupola." By J. E. Hurst. Published by Penton Publishing Company, Cleveland, Ohio.

The Journal of the Institute of Metals. Vol. XLII. 1929.

At the Annual Meeting of the Institution of Automobile Engineers it was announced that Sir Herbert Austin would be President of the Institution for the forthcoming Session, the Vice-Presidents being Mr. C. R. F. Engelbach, Mr. L. H. Pomeroy, Mr. W. J. Tennant and Mr. W. A. Tookey.

The summer visit of the Institution will this year be held on Thursday, June 26 to Saturday, June 28, inclusive.

WELDED STRUCTURES.

(*Continued from page* 208.)

of approximately $2\frac{1}{2}$ tons. It has been constructed by Messrs. A. Reyrolle and Co., Ltd. These illustrations serve to indicate the enormous strides being made in the use of welded construction, and show that there is scarcely any limit to its application once it has proved itself capable of meeting specifications. Like all new processes, welding is suffering from the conservative spirit which exists in British engineering, but while progress may be delayed, developments will continue to be made and the use of welding will continue to increase in value.

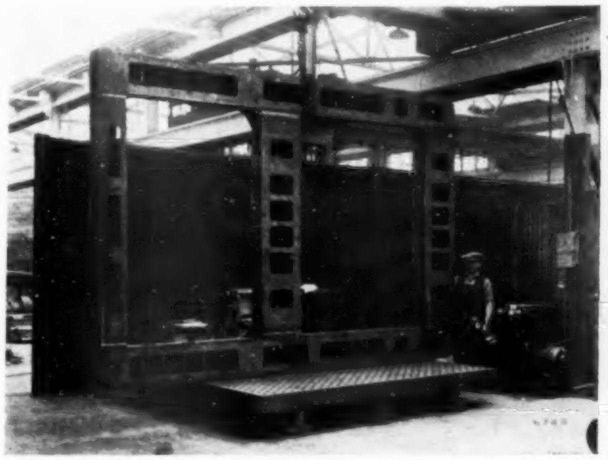


Fig. 5. Welded Steel Bedplate.

In the design and manufacture of these welded or fabricated steel parts, the relative costs of material and welding have to be carefully considered. The available plant for rolling and bending is also an important factor in the design. It is possible to have two forms of steel construction, both equally suitable. In the one the cost of material is low, but the cost of cutting, bending, and welding is high. In the other the cost of material is high, but the cost of welding is low. The best design must, of course, have the lowest combination of material and welding costs. Another fact to be considered is that for rotating machinery the frames, spiders and other parts all have a round form, whereas plates obtained from the steel rolling mill are rectangular or square in form. To keep down the cost it is essential so to design the parts as to make use of the rectangular plate to the fullest extent.

BRITISH MANUFACTURERS AND AUSTRALIA.

A private meeting took place recently at Australia House between Mr. J. E. Fenton, Australian Minister for Trade and Customs and 130 representatives of British traders and British trade organisations interested in the Australian market. Various points of difficulty regarding trade between the two countries were discussed. Sir Arthur Balfour, chairman of the British Council of the Australian Association of British Manufacturers, was in the chair. Statements were made by the following gentlemen :—Mr. Robinson (British Electrical and Allied Manufacturers' Association) ; Mr. J. Maughfling (Society of Motor Manufacturers and Traders) ; Mr. Claydon (Envelope Makers' and Manufacturing Stationers' Association) ; Mr. W. G. Sidebotham (Steel Trap Manufacturers' Association) ; Mr. F. Priest (Enamelled Hollow-ware Manufacturers' Association, and Ernest Stevens, Ltd.) ; Mr. Eric Sellman (Sellman and Hill, Ltd.) ; Mr. W. Mawle (Imperial Typewriters, Ltd.) ; Mr. V. Beaumont (Wolverhampton Chamber of Commerce) ; and Mr. Langham (British Aluminium Co., Ltd.).

The Federation of British Industries, the Association of British Chambers of Commerce, the National Union of Manufacturers, the British Engineers' Association, and many others were also represented.

DROP-STAMPING NON-FERROUS ALLOYS.

(*Continued from page* 194.)

Should it be found that there remains a tendency for the stampings to stick in the dies the application of a thin wash of graphite or French chalk will assist in avoiding them becoming firmly embedded. It is evident that these lubricants are in a different category to oil, in that they are not efficient by virtue of any mild explosive properties. They are lubricants, however, and tend to render more smooth dies which are not particularly well finished. In the event of a stamping becoming obdurate, and refusing to be removed in any ordinary way, the application of cold water to the stamping will contract it when the die is expanded, and so make removal more simple.

Extruded bar is probably the best stock bar which can be used for the making of non-ferrous stampings. Ingots can be used, but it is advisable to subject them to hot working before stamping is attempted. In the ingot form some of these stamping alloys are rather friable, and tend to break up if they are violently stamped in their as-cast condition. The application of preliminary forging largely removes this possibility. Extruded bar is, on the whole, excellently sound material, but on occasions it is found to be piped or similarly internally unsound. If stamping-off the bar is not to be done, the stock will have to be cut into pieces, and if this is done so that the presence of internal flaws are revealed, much unnecessary expense can be avoided. It is therefore suggested that the cutting be done so that the centre portion remains attached and on breaking this off by means of a blow with a hammer the soundness of the centre of the material is instantly revealed.

The higher tenacity brasses are not too easily machined, and it is generally true that this property is improved when the material is left in the worked condition. On the other hand, cold-worked non-ferrous alloys are somewhat prone to suffer from season cracking, and so an annealing at approximately 250° C. is to be advised when this occurs. Annealing at 650° C. has the effect of removing forging stresses which may cause trouble owing to warping when the surface of the metal is removed on machining. It may be mentioned that the 60/40 alloy containing 2% lead is an especially good alloy for free machining, the lead improving the machining qualities and increasing the strength at temperatures such as are reached in superheated steam practice.

ERRORS IN STEELMAKING.

(*Continued from page* 202.)

magnesite where required, with the compactness and strength of the fireclay to hold it together.

The Stopper.

This is a very important part of ladle equipment, and one which, if carelessly made or fixed, will almost certainly lead to serious trouble, often entailing the loss of a valuable cast or, at the best, much unnecessary labour in cleaning moulds, etc.

One of the greatest faults of the stopper maker is to wedge the sleeve bricks too tightly down. When this is done, the bricks are unable to expand longitudinally, and so the weakest one will split under pressure, allowing the stopper rod to burn through. All that is necessary in the matter of wedging, is to drive a flat nail lightly in between the top brick and the stopper rod. On the bricks expanding, this will slide up the rod and so avoid any undue pressure.

Another evil, and one which also causes much trouble is to have the sleeve bricks fitting too tightly on the rod, that is, not allowing enough space between the rod and the brick. A sleeve brick that has to be forced down the rod is only inviting trouble, as the expansion of the rod will almost certainly split it. The inside diameter of the sleeve should be at least $\frac{1}{8}$ in. larger than the diameter of the rod. Any that fit tightly should be rejected. Some works have a practice of binding the sleeve bricks with wire, and then daubing the whole from top to bottom with fireclay. I do not believe in this, as it is not possible for unburnt fireclay to remain "put"; it simply falls off and impregnates the charge with undesirable slag. Good quality bricks, fixed with care, are good enough without any covering.

PRINCIPLES AND USES OF WIRE ROPE.

(*Continued from page* 204.)

0·640 in., and the lay of the strand is 4·17 in. The core wire is 0·044 in., and the other wires 0·041 in. diameter. The lay of the outer wires in a straight strand is 1·97 in., and of the inner wires 1·125 in. Proceeding as before, the inclination of the six wires in the strand is $tan^{-1}\ \pi \times 0{\cdot}085/1{\cdot}125 = 13° 21'$, and of the outer twelve $tan^{-1}\ \pi \times 0{\cdot}167/1{\cdot}97 = 14° 55'$.

The wire has a tensile strength of 100/110 tons per square inch, the mean of which gives strengths of 0·1595 ton for the core wire, and 0·1386 ton for each of the others. The strength of the strand is $0{\cdot}1595 + 6 \times 0{\cdot}1386 \times 0{\cdot}973 + 12 \times 0{\cdot}1386 \times 0{\cdot}9663 = 2{\cdot}576$ tons, with an efficiency of $2{\cdot}576/0{\cdot}1595 + 18 \times 0{\cdot}1386$, or 97%.

Assuming one thousandth of an inch clearance between wires, the strand diameter becomes 0·212 in., from which, using the measured rope diameter, the angle of the strand in the rope is $tan^{-1}\ \pi \times 0{\cdot}428/4{\cdot}17 = 17° 52'$. The estimated strength of the complete rope becomes $6 \times 2{\cdot}576 \times 0{\cdot}9518 = 14{\cdot}7$ tons, which gives a rope efficiency of $14{\cdot}7/6, \times 2{\cdot}655$ or 92·2%. The accepted value for the aggregate strength is 15·7 tons, whereas the calculation gives 15·9 tons, because the core wire is not grouped with the others, and its greater diameter and strength are allowed for. The guaranteed strength is 13·7 tons, which makes the calculated 14·7 tons to be 7·3% high, but this indicates the margin which the manufacturers require rather than an error in the theory. The strength of a rope is usually appreciably larger than the guaranteed minimum, and frequently exceeds it by 6%, so the calculated strength here is theoretically correct, but it should be multiplied by a factor—say, 0·97,—to give the probable strength, or 0·93 to find the guaranteed strength. When calculations of rope strengths are made it is usual to neglect the lays with the corresponding inclinations, the aggregate strength of the wires being multiplied by a factor, 0·87 here, for 6 × 19, which depends on the rope construction.

THE SANDBERG SORBITIC STEEL PROCESS.

(*Continued from page* 206.)

tests also clearly show that the process does not merely give a surface hardening, but that the treatment effect is produced throughout the head.

The high resistance to shock is due to the peculiar fineness of the structure of Sorbite, which also gives smaller surface particles for tearing away by abrasion, and thus greatly reduces the wear in service.

The Sandberg sorbitic process for the treatment of steel tyres is similar in principle to that described for rails. For practical reasons the tyres are allowed to cool after they have been rolled, and are then reheated to a temperature slightly above their critical range, upon which they are placed on a table, which revolves whilst the "Scotch mist" is sprayed upon their surface. After the tyres have thus been cooled through their critical range they are placed in bins, in which they even out in temperature and are relieved from internal stress. A minimum tensile breaking load of 70 tons per sq. in. is called for with these tyres, and is readily obtained without impairing the resistance of the tyres to the falling weight tests.

Brinell impression tests made upon cross sections of these tyres show that effective heat-treatment takes place throughout the whole area, and is not merely superficial.

Some Recent Inventions.

IMPROVEMENTS IN TESTING INSTRUMENTS.

TESTING equipment associated with the measurement of the mechanical properties of metals is usually bulky and somewhat costly, and it is interesting to refer to an instrument for measuring physical properties of materials used in the engineering industry which is portable, has a low initial cost, and is claimed to be capable of giving quantitative information of a very valuable character. With the aid of this device the usual physical properties, such as yield point, maximum tensile stress, reduction in area per cent., and Brinell hardness, are possible without involving the use of large and expensive machines, and with a considerable reduction in test-piece specimens.

The plan and elevation of the device is illustrated in Figs. 1 and 2, and as will be observed, the ends of the specimen are held in suitable jaws, which are pulled apart until fracture of the specimen occurs. The force applied to the specimen deflects a stiff spring, and the magnitude of this force is measured by determining the deflection of the spring by a magnifying index. The index consists of mercury or other suitable fluid moving in a glass tube of small bore, compared with the fluid-containing vessel subjected to the movement of the spring.

The use of stiff springs for indicating a force applied is, of course, not new, and fine-bore glass tubes connected to vessels with diaphragms or flexible sides, and containing mercury or other liquids, have been used for measuring small movements, but, it is claimed for this device, the com-

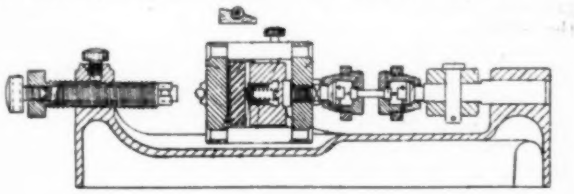


Fig. 1.

bination of these mechanisms is used in such a way that the fluid index mechanism is never subjected to high pressure; this is important from the point of view of stability. It is claimed that the sudden shock which occurs when the specimen fractures does not put the registering or indicating mechanism out of order, as is likely to occur if any ordinary multiplying index gear is used.

The suddenness of this shock is so great that dash pots have frequently been used to overcome the difficulties experienced. Combining the spring with one or more dash-pot cylinders furnished with pistons connected to the spring beam, the liquid from the dash-pot cylinders is led to a gauge glass for indicating the deflection. In this device, utilising the dash pot as the gauge vessel, the gauge cannot be made to furnish accurate records of the spring movement. It will be appreciated that if the piston and glands are so well fitted as to give no leak when the mechanism is moving slowly while the specimen is being loaded, a condition necessary to accurate gauge reading, then when the specimen fractures and violent and short-time movements are involved the amount of fluid leakage is so small that no effectual dash-pot action is possible. On the other hand, if the piston and gland pits admit of leakage sufficient to damp effectively the sudden and short-time movements experienced when the specimen fractures, then under the slow and gradual movements accompanying the loading of the specimen, during which it is essential that the gauge should read accurately, the total leak is so serious as to vitiate the reading.

In considering this difficulty it is necessary to remember that the loading must take place slowly in order to enable the gauge movements to be followed comfortably, and that, other things being equal, for a given leak orifice the amount of leak is proportional to time, and, with rapid movement, the amount of leak is proportional to the square root or some higher root of the pressure difference.

The variable volume fluid-containing device for operating the fluid index in machines constructed according to the improvements illustrated is without any dash-pot action whatever, thus the index errors are avoided.

Combined with the tensile testing instrument is an arrangement for measuring hardness. This is provided for by means of a screw which forces the material to be

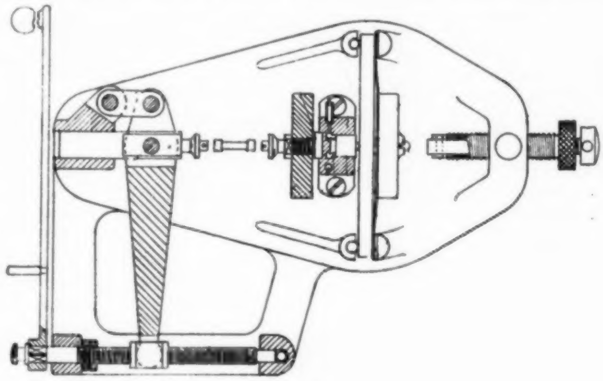
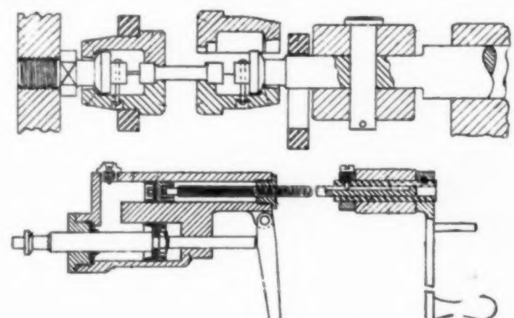


Fig. 2.

tested on to a hardened ball attached to the stiff spring and the same indicating device. Figs. 1 and 2 indicate how part of the instrument is arranged for measuring Brinell hardness. A hard steel ball is let into a raised part on the back of a disc; the raised part has a slit across it to enable the ball, when defective, to be dislodged and replaced by a fresh ball. The specimen to be tested is held up to the ball by means of a screw and a lock-screw tightened. The main screw is then rotated till its point drives forward the rod until the mercury in the tube reaches a predetermined position on the graduated scale. After a few seconds the specimen is removed and the diameter of the ball impression is measured and the hardness figure obtained from prepared tables. An enlarged illustration of the jaws used for tension specimen is shown in Fig. 3, while the hydraulic apparatus for applying the load is shown in Fig. 4.



Figs. 3 and 4.

In making the tension test, after the specimen is inserted in the jaws, a screw operated by a handle causes the trunnion end of a lever to move to the right, and as the fulcrum is anchored to the base casting, a pin moves slowly to the right and applies the pull to the specimen. The handle is turned slowly and uniformly, while the movement of the mercury over the scale is observed. With ordinary steel specimens the mercury will continue to move with the handle until the yield point is reached, when it stops momentarily, then recontinues until the maximum stress is reached, after which the mercury recedes until fracture occurs. The figures at which the yield point, maximum stress and fracture occur are noted. The elongation and reduction of area percentage are obtained in the usual

manner by measuring the specimen before and after practice.

320,704. L. H. Hounsfield, of Durrington Park Road, Wimbledon, London, S.W. 20. October 24, 1929.

IMPROVEMENTS IN FORGING MACHINES.

In connection with certain types of forging machines, it has been customary to make use of a gripping slide which usually has an extension provided for engagement with a bearing in order to guide the slide adequately. Very often, however, the extension and bearing of this slide are so located that scale and water, dropping off the gripping dies, have fallen on the extension, with the result that the scale and dirt have quickly worked into the bearings of the slide and made it extremely difficult to maintain them in proper working condition. The bearings rapidly become worn, with the result that the gripping slide tends to sag and rock and consequently the gripping dies get out of alignment and do not produce the effective results desired.

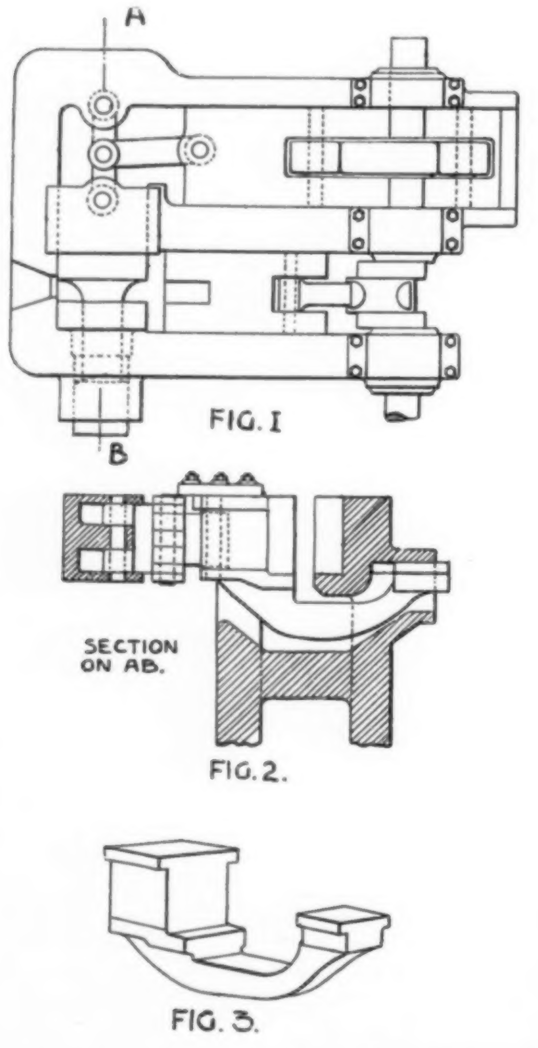


FIG. I

FIG. 2.

FIG. 3.

An improvement in design has for its object the removal of these difficulties, and is applicable to forging machines having a gripping slide with the extension and end bearing. In this improvement the arrangement is so constructed and located that it remains unaffected by any deposits of dirt and scale, and in consequence ensures more accurate working of the gripping slide and the elimination of faults frequently associated with machines of this type. The advantage of the improvements is concerned with the arrangement of partsand in the details of construction. The accompanying illustrations, Figs. 1, 2, and 3, indicate a portion of a forging machine in which the improvements are embodied, Fig. 1 illustrating a plan of the arrangement, Fig. 2 a sectional view showing the gripping slide and its operating toggle in elevation, and Fig. 3 illustrating the gripping slide in perspective. The main body of the machine is provided with a guide in which the heading slide is mounted for reciprocation, and any suitable means may be used for actuating this slide. Another guideway is provided within the bed or body, and a plunger mounted for reciprocation ; this plunger is operated by an eccentric or any other suitable means carried by the shaft. The guideways communicate at one end with a transverse recess which carries a shoulder for supporting a stationary gripping die. The bottom of the recess is extended beneath a shoulder and opens through one side of the bed ; this end of the recess is provided with bearings located laterally beyond the stationary gripping die and above the level of the shoulder. A gripping slide is mounted to reciprocate within the recess, and is provided with bearing flanges at its upper end for slidably engaging the bed. The construction of the bearings can obviously be varied to suit the manufacturer and user, it merely being essential that they serve to support the gripping slide in proper working position within the recess.

The gripping slide has an extension projecting from the bottom and so shaped that it works freely within the lower part of the recess and under the shoulder. The free end part of this extension is projected upwards and terminates in a bearing head having flanges adapted to slide on the bearings. It will be noted on referring to Fig. 2 that the engaging bearing surfaces formed by the bearings and the ribs are located well above the middle portion of the extension. With this improvement the elevated bearings renders it an impossibility for scale or dirt to work upwards to affect them, and as a result the objectionable features associated with other designs are eliminated and proper alignment of the dies is maintained.

319,131. W. L. Clouse, of U.S.A. Agent : F. B. Dehn, Kingsway House, 103, Kingsway, London, W.C. 2. September 19, 1929.

ELECTRIC INDUCTION FURNACES.

The performance of Metropolitan-Vickers electric induction furnaces in service has been the subject of considerable attention in the steel industry, especially with regard to the reliability of the equipment, the quality of the product, and the cost of operation. It is now known that the equipments installed have operated in such a way as to give complete satisfaction, and the placing of an order for the United Steel Companies, Ltd., is significant as indicating that the furnaces have passed creditably through what may be regarded as their probationary period.

The results obtained, apart from demonstrating reliability, have confirmed that the coreless induction furnace gives accurate control over the composition of the product and therefore over the quality of steel produced. As regards cost of operation, actual records over six months' operation in a large steel works show that steel of crucible quality has been melted at an overall cost, including labour, power, overhead and depreciation charges of about £9 per ton, as compared with £16 per ton for the crucible process. The ¼-ton furnace melts its charge in about one hour, and the records above mentioned show that for an output of about 50 tons per month the average overall power consumption has been about 770 k.w.-hours per ton.

Many authorities on steel production assert that furnaces of this type will soon completely supersede the old crucible process which has held undisputed sway in the steel industry for about one hundred and fifty years, and that they are destined to play an important part in the production of alloy steels to meet the increasingly exacting requirements of modern engineering design.

Does the Scleroscope Give the True Hardness of Chilled Rolls?

By John Shaw.

FOR some considerable time it has been recognised that the surface hardness of chilled rolls has had a definite bearing on the finish of such varied material as auto-sheets, non-ferrous sheet and strip, paper, and textiles. Unfortunately, so far as ordinary cast-iron chilled rolls are concerned, hardness of face and brittleness go together. Thus there is a limit, at least for steel and non-ferrous work, to which the surface hardness of iron rolls can be taken with safety.

It is seldom realised how frail chilled rolls are, not because of inherent weakness in the metal itself, but due entirely to the composite structure. If it is remembered that the outer white shell expands or contracts at twice the rate of the inner grey core, and that this is further aggravated by the heat being generated in this outer shell first, whether it is frictional or derived from the heated material being rolled, you can form some idea of the internal stresses set up that tend to rend the roll asunder. It may be taken for granted that sheet rolls are rarely broken by pressure, but almost invariably by the lack of elasticity in the inner core. Judged by the tensile strength this metal may be excellent. In fact, its very strength and compactness may be the cause of its failure. It is more liable to slight fracture in the centre under the variable expansion.

Admitting that hardness of face is a desirable quality for some work, this has necessitated the finding of some means of measuring hardness. The Brinell test for several reasons is not suitable, the principal one being the imprints left behind on the surface of the roll would mark the sheet or cut the textile fabric. To attempt to grind these out is an expensive job, and is often impossible, as it would decrease the diameter of the roll, which is generally received dead to finished size.

This has led to the general use of the scleroscope as the instrument for testing the hardness of chilled rolls. For some years, both as a maker of chilled rolls, and, later, as inspector of same for several clients, I have had serious doubts as to the reliability of this method. Certainly different instruments give variations of from 5° to 10° on the same roll tested in the same area. Recently two papers have been published dealing with this subject. These have led the present author to publish confirmatory results.

The first paper by Melaney ("Blast Furnace and Steel Plant," January, 1930) considers this question in relation to sheet rolls for steel. His chief points are "No two manufacturers have identically the same practice, and a roll that is suitable in one plant will give only a mediocre result when used in a mill having a different practice; and let me say there are no two mills using identically the same practice. Rolls, therefore, of different character are needed in each plant to obtain the same results. To specify, therefore, a hardness figure for rolls doing the same type of work even may be wrong." Melaney doubts if scleroscope readings are a true index of the hardness of the face. He states: "Any surface, whether soft or hard, will give resistance to impact, depending on how smooth the surface is finished. Even the smoothest surface will show quite rough if sufficiently magnified."

There is ample evidence that this is true. Recently, in examining a roll from the Continent that on the first dressing showed a drop of 5° from the reading taken when the roll was received, it was found that the surface grinding, while quite good enough for the work it had to do, had not an equal finish as at first. Grinding with another stone with little cut restored both finish and original hardness number. Melaney also points out that the instrument must be held perfectly plumb if correct results are to be obtained. Those who regularly use the scleroscope overcome this trouble by fitting the instrument with an aluminium angle plate. To this is fixed a circular level, which tells the investigator if his tester is plumb, and allows him to devote his whole attention to the rebound figure. Melaney continues: "But granting both these conditions have been fulfilled, the scleroscope hardness is no guide to the roll-face behaviour when placed in service. It has been found in practice that many times a roll which does not show the required hardness gives very little trouble from tail marks, while another roll registering much harder by this test marks up badly. A chilled roll is a composite, comprising a chilled face of ¾ in. superimposed over a grey inner centre that varies in physical characteristics quite materially—in rolls supposed to be alike—and showing the same chemical analysis. This is what determines, more than its actual face hardness, its resistance to indentation or tail marking, and the actual days' service it will give before being discarded."

A further point bearing on the question of hardness is the growing practice of running a pair of rolls together for some time, or to employ a small hard roll to traverse the surface of the roll after grinding is finished. In this way the surface hardness is raised about 5°. While this may not be objectionable for paper rolls, it means in the case of sheet rolls for plates that this false surface is lost with the first dressing of the rolls. Several cases are known where tail marking has taken place after this. The second paper, by Dr. Otto Keune ("Der Papierfabrikant," No. 42, 1929), is of great importance. After describing the construction of the Brinell and scleroscope instruments, and showing certain errors, he makes the following statement, which I propose to quote in full, as it puts in terse form findings similar to my own:—

"Although the foregoing remarks, if rightly considered, in no way impair the usefulness of the scleroscope test as regards its advantages over the Brinell test, we now propose to discuss one point which makes it extremely questionable whether the method can be applied to the testing of chill cast iron. Table 2 contains the result of the average of 100 blows carried out with two different instruments on the same test pieces.

TABLE 2.

Test Piece.	Average of 100 Blows on Free-hand Test in Scleroscope Degrees.		Brinell 10/3000/30
	Machine (1)	Machine (2)	
Hardened steel, standard 96 to 98	98·2	98	677
Chill cast iron	87·0	77·2	541
Chill cast iron	82·3	71·7	504
Chill cast iron	72·2	63·5	444

"It will be seen that the two instruments used for the tests agree with regard to the standard piece of hardened steel. But when we come to the measurements on chilled iron castings we find deviations of about 10°. I first attributed these surprising and unexpected differences to slight variations in the construction of the two machines. As a matter of fact the diamond points of the drop-hammers are shaped slightly differently in the two apparatus, as will be seen from Fig. 1 (see original paper), which shows the imprints on the same chill casting, magnified 100 times. This assumption is also supported

(*Continued on page* 220.)

Business Notes and News

The Iron and Steel Institute.

The Council of the Iron and Steel Institute have this year decided to award Bessemer Gold Medals to two men distinguished in science and industry, namely, Dr. Walter Rosenhain, F.R.S., who has for many years held the position of Superintendent of the Metallurgy Department of the National Physical Laboratory, and whose work in the advancement of metallurgical science has received worldwide recognition; and Mr. Eugene Schneider, who owns the famous Schneider Establishments at Creusot, France, and has, besides, extensive interests in the iron industries of Central Europe. It will also be remembered that Mr. Schneider held the office of President of the Institute in the years 1918-19, when the Institute celebrated the Fiftieth Anniversary of its foundation. The President, Professor Henry Louis, will present these medals on the occasion of the annual meeting on May 1.

On the Council of the Institute certain changes have lately taken place. The Hon. Roland Kitson, D.S.O., and Professor C. H. Desch, F.R.S., have been elected Vice-Presidents, while Mr. Fred Clements, of Park Gate, and Mr. J. S. Hollings, of Brymbo, have been elected Members of Council.

By arrangement with the Wardens of the Worshipful Company of Blacksmiths, the Council nominate annually two Members of the Institute for admission to the Freedom and Livery of the Company. The Council's nominees this year are Mr. G. C. Bond, of Nottingham, and Dr. R. H. Greaves, of the Research Department, Woolwich.

Geared Oil Locomotive.

Representatives of British and foreign railways are showing considerable interest in a new geared oil locomotive which has just been completed at Leeds for the Junin Railway in Chile.

Described as a remarkable engine, it is the biggest of its kind ever made in this country, and it is expected that its introduction in Chile, where lack of water and coal creates a difficult railway problem, will lead to a big development in locomotive manufacture and, possibly, the creation of a new industry in Leeds.

Its main features are a five-ton gearbox, giving four speeds forward and four reverse, the absence of vibration, and the low working costs (under 3s. an hour). The new engine is to be shipped in one piece.

The "Silver Bullet."

An attempt to break the world's land speed record is to be made at Daytona between March 15 and 31 in the new car recently constructed at the Sunbeam Motor Works. The car is just over 31 ft. long and is very narrow, the wheel track being only 4 ft. 11 in. The steering wheel, which has very little lock, has to be removed before the driver can take his seat. To facilitate steering at high speeds, rifle sights have been fixed. The body of the car is of aluminium, and two super-charged twelve-cylinder engines, which have been specially designed for this attempt on the speed record, will give an engine speed of 2,400 r.p.m. At this speed the gearing will render the car capable of 125 miles per hour in first gear, 166 miles per hour in second gear, and 248 miles per hour in top gear. It is computed that it will take about three miles to attain its maximum speed, and about four miles to pull up afterwards. The car, which weighs about three tons, is now at Daytona.

Lectures on Steel-melting Practice.

A series of six lectures has been commenced on steel melting practice at the Sheffield University. All who are engaged in the various processes of steel making can attend. The lectures, which commenced on March 5 and are being continued on successive Wednesdays at 7 p.m., are being given by J. N. Kilby and Dr. P. Longmuir. Each lecture is arranged to occupy about one hour, to be followed by a discussion, in which members of the class will have opportunities for raising practical difficulties for consideration.

The lectures have been arranged to provide useful information on the principles relating to the melting and production of all classes of steel by the crucible and open-hearth processes. The arrangement is an extension of the scheme of technical instruction for workers in the Sheffield trades and has been prepared by the Applied Science Department at the University.

High Voltage Research.

A new high voltage research laboratory installed by Metropolitan Vickers, Ltd., at their Trafford Park Works, was recently officially opened by Sir Ernest Rutherford. In a subsequent speech he made reference to the need of high potentials to facilitate the next steps in the investigation of the physical problems of the atom.

Until recently, he said, potentials higher than 200,000 volts were seldom available in the laboratory, and it was only by much improved technique that it was possible to maintain such a potential on the terminals of a highly exhausted tube, but there was need of still higher voltages in order to test insulation and transmission lines, and apparatus of the transformer type had been used to give voltages from 1,000,000 to several million. The importance of this new method of research had led the Metropolitan Vickers Co. to arrange for such a high voltage apparatus at their own works. These installations were not only necessary for electrical engineering, but also as opening up new and interesting fields of physical research, especially into the phenomena of electrical discharge in gases at different pressures where current explanations contained only a small part of the truth.

The new laboratory will be engaged specially in the testing of insulating materials required to resist high voltage, and a pressure of 1,000,000 volts will be regularly employed. As is now well known, high transmission voltages can effect great economies in electrical supply systems, but there are at present many problems awaiting solution in connection with the maintenance of insulation at these high potentials. In this laboratory the voltage is derived from the use of two 500,000 volt 500 kVA. 50-cycle transformers in series. Auxiliary equipment includes an impulse generator capable of giving impulse voltage up to 1,500,000 volts. A very large proportion of modern high voltage apparatus depends on oil for its insulation, and it has been found essential to carry out full-scale tests if reliable data for design are to be obtained. In the new laboratory on oil tank, 25 ft. in diameter and 10 ft. in depth, has been erected for this purpose, where special tests already begun on the effects of impurities will be continued.

Industrial Pulmonary Disease.

The Medical Research Council has appointed the following committee to advise on the further investigation of pulmonary silicosis, and of other pulmonary conditions associated with the inhalation of dusts arising from industrial processes:—Arthur J. Hall, M.D., F.R.C.P., Professor of Medicine in the University of Sheffield and Senior Physician to the Sheffield Royal Hospital (chairman); A. E. Barclay, O.B.E., M.D., Lecturer in Radiology to the University of Cambridge; J. C. Bridge, F.R.C.S.E., H.M. Senior Medical Inspector of Factories, Home Office; S. L. Cummins, C.B., C.M.G., M.D., Professor of Tuberculosis in the University College of South Wales and Director of Research to the Welsh National Memorial Association; E. H. Kettle, M.D., M.R.C.P., Professor of Pathology, St. Bartholomew's Hospital and College, London; E. L. Middleton, M.D., H.M. Medical Inspector of Factories, Home Office (secretary); M. J. Stewart, M.B., F.R.C.P., Professor of Pathology in the University of Leeds; Cecil Wall, D.M., F.R.C.P., physician to the London Hospital and to the Brompton Hospital for Consumption and Diseases of the Chest.

The committee will survey the present state of knowledge, will advise the council on new lines of inquiry that may be profitably pursued, and will assist in the supervision of such investigations as it may be decided to initiate or support. The work will be directed particularly towards obtaining in co-operation with the Factory Department of the Home Office more accurate knowledge of the causes and diagnosis of silicosis and of other industrial pulmonary disorders. The need of better knowledge of these subjects has been emphasised by the recent report of the Silicosis (Medical Arrangements) Committee, whose recommendations to the Secretary of State for extended research work have been referred to the council by the Home Office.

Readers may be interested to know that Wild-Barfield Furnaces will be exhibited at the Leipzig Fair and also at the Achema Exhibition at Frankfort o/M. Visitors to either of these exhibitions will be able to witness demonstrations.

Some Contracts.

The United Steel Companies, Ltd., have placed with the Metropolitan-Vickers Electrical Co. an order for an electric induction furnace for steel melting to be installed at the works of Messrs. Samuel Fox and Co., Ltd., Stocksbridge. The furnace will be of ½-ton capacity, and of the Metropolitan-Vickers standard design, which aroused considerable interest when the first installation was made a little more than a year ago. Since that time furnaces of this type installed at a number of works in Sheffield and elsewhere, including the works of Messrs. Vickers-Armstrongs, Ltd., and Messrs. Hadfields, Ltd., have been in continuous commercial operation, producing steels formerly made by the pit-fire crucible process.

Metropolitan-Cammell Carriage, Wagon and Finance Co., Ltd., have received an order for 20 patent screw-over four-wheeled all-steel tipping wagons for the Great Western Railway Co. They are to be used for ballasting and permanent way maintenance and each will have a capacity of 15 cubic yards.

The Butterley Co., Ltd., are to supply 105 of the standard type A all-steel containers for rail and road transport, and also 350 of the type B containers, to the order of the London Midland and Scottish Railway Co. The Metropolitan-Cammell Carriage, Wagon and Finance Co., Ltd., have received an order for 120 of the type A containers.

The Great Western Railway Company announce that 100 special trucks are to be built at their Swindon works for the conveyance of motor cars from factories in Birmingham and Oxford to the docks for shipment, and to other parts of the country. Orders are also to be placed for 50 more covered containers and 25 insulated containers for meat and other perishable traffic. Extensive alterations are to be carried out at Keynsham Station, Somerset. The platforms will be extended, and additional siding accommodation provided to cope with the increasing traffic which has resulted from the removal of the works of J. S. Fry and Sons, Ltd., to Somerdale.

The English Electric Co., Ltd., Preston, Lancashire, have received orders for trackless trolley omnibuses from the corporations of Pontypridd and Southend-on-Sea. The vehicles ordered for Pontypridd number seven, and will be of the single-deck saloon type, mounted on three-axle chassis, with a seating capacity for 32 passengers; the order from Southend-on-Sea is for two double-deck covered-top vehicles mounted on three-axle chassis, each seating 59 passengers, and having air brakes operating on all wheels. The same makers have secured an order from Christchurch, New Zealand, for three complete three-axle trolley omnibuses.

The Vulcan Motor and Engineering Co. (1906), Ltd. Southport have received from Birmingham Corporation an order for 35 double-deck omnibus bodies, each with a seating capacity for 51 passengers.

Crossley Motors, Ltd., Gorton, Manchester, have received a third repeat order from the Race-course Betting Control Board for 11 30/70 h.p. 4-cyl. six-wheeled vehicles.

The Bristol Tramways and Carriage Co., Ltd., of Bristol have received the following repeat order :—Four 40 h.p. 4-ton goods chassis (Shell-Mex, Ltd.), one 32-seater one-man-operated "Superbus" on a 4-cyl. four-wheeld chassis (Aberdare Urban District Council Tramways), one 4-cyl. four-wheeled passenger chassis (Newcastle, Staffs., Motor Co., Ltd.), 20 40 h.p. 4-ton goods chassis (British Petroleum Co., Ltd.), two 4-cyl. four-wheeled passenger chassis (Rotherham Corporation)

The Westinghouse Brake and Saxby Signal Co., Ltd., of King's Cross, N. 1, and Chippenham, Wilts., have received from the Birmingham Railway Carriage and Wagon Co., Ltd., Smethwick, a contract for 400 "Prestall" vacuum-brake sets for the 30-ton all-steel goods wagons which that firm is building to the order of the Buenos Aires and Pacific Railway Co., Ltd.

The Clarence Dock Power Station Committee, Liverpool, have recommended acceptance of the following tenders :—For switchgear to the value of £20,000, the British Thomson-Houston Co., Ltd., Rugby; for steel chimneys to the value of £7,700, Markham and Co., Ltd.

An important contract for the erection of a 3,000,000 cubic feet spiral gasholder at the Howdon-on-Tyne works of the Newcastle and Gateshead Gas Company, has been placed with the Furness Shipbuilding Co., Ltd., of Haverton Hill. A considerable quantity of material will be required, and it is expected that the work of construction will take about twelve months.

The Newcastle and Gateshead Gas Co. are showing considerable enterprise in developing their undertaking on the most modern lines. They are engaged on big extensions at their Redheugh works and are installing new purifying and other plant, some of which will compare, in point of size, with the largest of its kind in the country.

More than 56,000 tons of structural steel will be required in the construction of the new Montreal terminals for the Canadian National Railways, according to the estimate of the engineers in charge. It is also estimated that 350,000 barrels of cement will be used. For terminal buildings, freight and passenger facilities, and other purposes, 385 acres of land have been acquired, and the plans call for the construction of 80 miles of new track and the rearrangement of 12 miles of main line. The project has been approved by the Canadian Parliament, and during the next five years expenditure will be at the rate of about £2,000,000 a year. It is estimated that a total of £10,000,000 will be needed to complete the project.

The Canadian Pacific Railway has applied for permission to construct a number of short branch railway lines. The principal of these are from Vaudreuil, on the Ontario-Quebec line, to Windmill; from Tempest, on the Taber line, in a south-easterly direction; from Duval, on the Pheasant Hills branch, in an easterly direction; and from Dunelm, on the South Current line, in a south-westerly direction. The cost of the new lines is not to exceed £10,000 a mile.

Expenditure on public works in Toronto during the current year is expected to amount to £650,000. Of this total £360,000 will be devoted to improvements to the water supply system, involving, among other works, the extension of the high-level pumping station and the construction of a new 42-in. water main from the pumping station to the water tower at Roselawn Avenue. £150,000 will be spent on bridges and £130,000 on sewerage extensions. In addition to the above programme, £1,200,000 will be spent on new roads.

A new railway is now being constructed on the Burma railways from Taungwingwyi to Magwe and thence, on the opposite side of the Irrawaddy River, to Pakokku. When this line is completed it is proposed to construct a spur line from Magwe to Akyab, on the Bay of Bengal, a distance of 175 miles. The Assam-Bengal Railway has prepared plans for an extension of the Laksam-Chittagong line southwards to Akyab, involving the construction of a railway bridge across the Karnaphuli River. By the construction of the two lines railway connection would be provided between Calcutta and Rangoon.

George Brown and Co., Greenock, have received a contract for a salvage vessel for Canadian owners. The ship will be 130 ft. in length and will be fitted with Diesel engines suppfied by Worthington-Simpson, Ltd., London.

The Central Electricity Board have placed contracts amounting in all to approximately £150,000, for 132 kilovolt transformers in the area of the Mid-East England electricity scheme with the following firms :—Messrs. Ferranti, Ltd., Hollinwood, Lancashire; the Fuller Electrical and Manufacturing Co., Ltd., 5, Chancery Lane, London, W.C. 2; the General Electric Co., Ltd., Witton, Birmingham.

A contract for the installation and exploitation of automatic telephones in Athens, Piræus, and the suburbs, has been signed between the Minister of Communications and Siemens and Halske, of Berlin. This contract was awarded five years ago to a British company, but was cancelled owing to this company failing to carry it out.

The Municipality of Georgetown, Penang, have placed the following orders in connection with their electric supply extensions :—British Thomson-Houston Co., Ltd., Rugby, turbo-generator and plant; cables, etc., Siemens Bros., Woolwich, and Callender's Cable and Construction Co., London. The value of these orders amounts to about £80,000.

Some Contracts—continued.

Contracts to the value of £250,000 have been secured by the British Insulated Cables, Ltd., Prescot, to supply and lay 66,000 volt cables for one of the large power companies operating in London. They have also received the contract to supply and lay a new G.P.O. trunk telephone cable for 42 miles between Manchester and Chester, to make 96,000 yards of underground and submarine cable for Shanghai, and 20,080 yards of underground cable for Australia.

The London and North Eastern Railway have placed contracts with the Metropolitan Cammell Carriage, Wagon, and Finance Co., Ltd., Birmingham, and with Head, Wrightson and Co., Ltd., Thornaby-on-Tees, for 100 40-ton bogie plate wagons. An order for 25 50-ton wagons has also been given to the Metropolitan Cammell Carriage Co. Although these are primarily intended for the conveyance of bricks, they are equally suitable for ironstone, slag, and other heavy traffic.

The Staveley Coal and Iron Co. have secured a contract for the supply of 30-in. cast-iron pipes for the Giza sewerage system, Cairo.

The Liverpool Corporation has placed a third repeat order with Messrs. John Thornycroft and Co., Ltd., for 40 6-cylinder 6-wheeled omnibus chassis, following experimental and test orders for similar chassis which had been placed with that company.

The refractories department of General Refractories, Ltd., Sheffield, has secured, in face of severe foreign competition, the order for the refractory linings for the zinc reduction furnaces to be erected at Tunis, in North Africa.

The Dewsbury Town Council have placed orders for a rotary converter, to cost £1,200, with the Harland Engineering Co., Ltd., Alloa; for a motor converter, to cost £3,000, with Bruce, Peebles and Co., Ltd., Edinburgh; for a switchboard, to cost £1,500, with the Electric Construction Co., Ltd., Wolverhampton; and for cable, to cost £2,500, with Power and Lighting Cables, Ltd., London.

The English Electric Co., Ltd., Preston, have received the following orders for trolley omnibuses: From Pontypridd for seven single-deck, saloon-type vehicles; from the Southend Corporation for two double-deck, top-covered vehicles; and from Christchurch, New Zealand, for six three-axle chassis and equipment.

General Refractories, Sheffield, have received an order from the Shilton Brick and Tile Co. for three Williams tunnel brick dryers, intended to supersede partially the system of drying bricks singly on concrete floors heated by exhaust steam.

The Westinghouse Brake and Saxby Signal Co., Ltd., have received from the Birmingham Railway Carriage and Wagon Co., Ltd., an order for 400 "Prestall" vacuum brake sets for wagons which the latter company is building for the Buenos Ayres and Pacific Railway.

The Doncaster Corporation are to install additional high-pressure cables, transformers, and switchgear in connection with the supply of electricity to the new factory of British Bemberg, at Wheatley, and have placed contracts with the Enfield Cable Works for cables, £4,449; with the Yorkshire Electric Transformer Co. for transformers, £1,108; and with Metropolitan-Vickers Electrical Co. for switchgear, £1,685.

A large order for cast-iron pipes has been awarded to the Staveley Coal and Iron Co., Staveley Works, near Chesterfield, by the Public Works Department of Egypt.

The keels of two cargo steamers have recently been laid by William Beardmore and Co., Ltd., of Dalmuir, to the order of John Campbell and Son, of Glasgow. The carrying capacity of each will be about 9,000 tons deadweight. The vessels will be fitted with reciprocating engines supplied by the builders, and working in conjunction with Bauer-Wach low-pressure turbines. They will be constructed under the supervision of Crookston and Co., of London. Beardmore and Co. have also received the contract for reconditioning the Carron Company's steamer *Carron*.

Does the Scleroscope Give the True Hardness of Chilled Rolls?

(*Continued from page* 217.)

by various observations made by other firms and with other instruments. Here, too, there were similar differences when using the two different types of instruments on hard-chilled castings, although the readings as taken on the hardened steel standard pieces practically agreed.

"My supposition in this particular connection is not, however, confirmed by further exhaustive tests which I have carried out. On the other hand, I found that even scleroscopes of the same design exhibited pronounced deviations in the range of measurement applicable to chill iron. Table 3 affords proof of this.

Table 3.

Scleroscope No.	Type.	Average Scleroscope Hardness Figures on a Chilled Casting.
1	I.	87
2	I.	87
3	I.	78
4	I.	81
5	I.	85
6	I. older pattern	81
7	II.	77
8	II.	80
9	II.	84
10	III.	81
11	III.	83

"The deviations in the readings of the several instruments when testing chill castings are so large as to be no longer acceptable for practical requirements. Just as long as there is no uniformity in the readings of the several instruments in the range of hardness involved for chill castings, then hardness readings in scleroscope degrees are ambiguous. According to whether the tests are taken on instruments similar to type I. or to type II., in Table 2, the difference in the measurements obtained will be so wide as to lead to differences between the manufacturer and the consumer."

Nothing I can say will give a clearer view of the points at issue, and I am leaving it there, and detail a few of the examples I have met. I have before me 16 charts giving the hardness figures of eight rolls; eight came with the rolls from the makers, the others gave the customers' readings. In no case do they agree within 5° of each other. In five cases I checked the rolls with the customer's instrument and found them correct. In the remaining three I took another instrument of the same type and after testing both on the steel standard found an average difference of only 3°.

The London manager of one of the largest Indian steel works recently raised this question with me, stating that out of numerous sheet rolls received from the Continent the scleroscope readings at the works were always 7° to 10° below the charts giving the maker's readings. Confirmation also comes from the mill manager and chief of the research department of the largest steel works on the East Coast, where the readings were always 5° to 10° lower than reported. Several of these rolls I checked. Similar discrepancies have been found on testing rolls for rubber. Four recently tested gave an average of 6° less on one instrument than another. These examples and others quoted are too numerous and too widespread to be attributed to either incorrect reading or occasional failure of the machine. Nor can the variation be attributed to sharp practice by either maker or customer. In a number of cases I have tried both instruments, and found both readings approximately correct. Neither is the reading always in favour of the maker. I know of a case where a maker refused an order because of the hardness figure asked. Yet, on another instrument, with the roll of similar analysis, this figure was obtained. The most disturbing feature is the fact that two instruments may each give a correct reading on the steel standard, yet vary as much as 10° on the same chilled casting. This point needs further investigation, and if generally confirmed makes it impossible to rely on figures obtained by the scleroscope on chilled rolls.

IRON AND STEEL REPORT.

The past month has witnessed little, if any, improvement in the general position of the iron and steel trades. Fortunately for iron producers, a large proportion of the output of some of the leading furnaces is going into consumption at associated pipe foundries, and so far as the Midland area is concerned the fact that during the past twelve months certain plants have ceased to produce entirely has so far prevented any important accumulation of stocks. The unsatisfactory feature of this section of the market is that buying for forward delivery has been on a very small scale, and there is little sign of users departing from this policy.

It was thought that when Staffordshire and Derbyshire pig-iron makers recently decided to maintain current prices until, at least, the end of April, when, presumably, the question of prices will again come under consideration, some renewal of confidence among consumers would make itself felt in the volume of contract buying, but unfortunately this has not developed. The bulk of the business that has been booked in most centres has consisted of the addition of relatively small tonnages with a view to helping out old contracts. The past few weeks have seen a gradual diminution in the aggregate deliveries of iron to foundries. In the case of light castings, however, there are hopes of a certain amount of improvement as the season advances.

With regard to future price prospects in the foundry iron section, the outlook is not by any means clear. Consumers, on the one hand, seem to be prepared to act with caution in the hope of securing supplies later on on more favourable terms. On the other hand, there is no doubt that margins, even for the most efficient blast furnaces, are far from satisfactory, though some easiness that has developed in the coke market has helped to reduce production costs.

To sum up, it may be said pretty definitely that the present state of the demand for foundry pig iron is anything but favourable to a bullish market, and that values are extremely unlikely to register any further advances, even if concessions to users are not made. Meanwhile, quotations all round are unchanged at levels which, for the most part, have operated for some months.

In respect of finished iron, certain districts are experiencing a not unsatisfactory demand for the best qualities of bars, but other grades are attracting little attention, and recent buying operations have been mainly of a day-to-day character, the lower qualities for nut and bolt making, in particular, finding orders scarce in view of the competition of the much cheaper Continental materials.

Steel rollers have been complaining not only of the scarcity of any important new orders, but also at the slow rate which, in most instances, delivery specifications are being received against contracts placed some time ago. With few exceptions, this has been the general experience of the rolling-mills in most districts. It is significant that within the past few days the shortage of orders for rails has compelled the management of one of the principal plants on the North-West Coast to put their steel workers on day-to-day engagements, and unless the position improves shortly the prospects are that at this particular works there will be a temporary closing down of plant. A fair quantity of plates and other steel materials is going into consumption at the shipbuilding centres, though in the aggregate it is much below that at the corresponding period of last year. Structural engineering, another very important outlet for steel, is taking relatively small quantities against old contracts, and consumption among textile and other engineering concerns also is much below normal. Bright spots are to be found in certain branches, however, notably in heavy electrical engineering and among speciality firms, whilst locomotive builders, also, are taking not unimportant quantities of frame and boiler plates. There is a moderate call for bright-drawn bars, but in most other respects both rollers and re-rollers in this section have poor order books. Steel values all round, however, have maintained their firmness during the period under review.

THE LEIPZIG FAIR.

The Spring Fair at Leipzig opened under what may be regarded as favourable circumstances, and it is expected that a considerable impetus will be given to industry as a result of the efforts made. The fair has developed to such an extent that every year increases its importance as a means of furthering Germany's export trade. Considerable energy has been displayed in preparing for this fair, and the organisers feel justified in asserting that a big increase in export trade may be anticipated. The number of countries that find it profitable to display their products is gradually increasing, and while the exhibitors are taking the advantage of interesting representatives of foreign countries, opportunities are afforded of studying the nature of articles and goods, and this enables the German manufacturer to understand the various factors with which he has to compete in various parts of the world. This may in some measure compensate for the presence of foreign exhibitors at the fair. The question has been discussed in Germany for years, but it may now be considered to have been settled, and foreign manufacturers are encouraged to exhibit, and a welcome is extended just as in the case of foreign buyers.

At the moment the condition of industry in Germany is somewhat depressed, and much depends upon the foreign buyer. German producers are showing their best, but their primary aim is, apparently, to show how well they have adapted their wares to the needs of foreign markets, and to display their improvements and novelties. The depression in Germany is illustrated by the fact that there are this year about 8,320 German exhibitors at the fair, against 8,900 last year, and the anticipations of home orders are great. Dependence on foreign buyers is certainly justified by results, and the organisers of the fair claim that there is a very close connection between the yearly increase of the foreign visitors to it and the growth of the value of Germany's export of finished goods.

Twenty-seven foreign countries are exhibiting this spring, of which two appear for the first time—namely, Poland and Chile. Italy is represented by more than 100 firms, and, while these show the well-known produce of their country, they also offer to the world specimens of its new industries. Evidence of the popularity of the fair may be judged from the number of foreign visitors who have attended during the last few years. The number of foreign visitors in 1924 was 13,500 ; in 1925, 17,200 ; in 1926, 19,610 ; 1927, 23,130 ; 1928, 29,750 ; 1929, 28,660. The value of the German export of finished goods was 5,190,000,000 marks in 1924, and it has risen steadily until it was 8,500,000,000 marks in 1928, and 9,451,000,000 marks in 1929, and it has been estimated that the value of the additional export orders obtained directly through the medium of the Leipzig Fair in the past two years has been £50,000,000 in each year.

We have been informed that Mr. E. P. Barfield and Mr. J. P. Coleman, of Wild-Barfield Electric Furnaces, Ltd., have left England for an extended visit to the United States of America.

Catalogues and Other Publications

Considerable advancement has taken place during recent years in the design and construction of strip rolling mills, and we have received a brochure illustrating the development of the Robertson cold-rolling mills for strip metal, which is full of interest. Many new features are now associated with their mills, and all those interested would do well to have a copy of this brochure, which is available on application to W. H. A. Robertson and Co., Ltd., Lynton Works, Bedford.

In the March issue of the *Welder* a very informative series of articles has been commenced, entitled "Weldings Under the Microscope," which is usefully illustrated with a number of photo-micrographs. This issue contains many other interesting features, including an article dealing with the strengthening and repairing of bridges by means of electric arc welding. The *Welder* is a bi-monthly magazine published by Alloy Welded Processes, Ltd., and will be sent to all interested on application.

MARKET PRICES

ALUMINIUM.

99% Purity		—
Castings, 2.L5 Alloy	lb.	1/3–1/8
,, 2.L8 ,,	,,	1/4–1/9
,, Silicon ,,	,,	—

ANTIMONY.

English	£40	10	0
Chinese	29	0	0
Crude	17	0	0

BRASS.

Solid Drawn Tubes	lb.	12¾d. & 13d.
Brazed Tubes	lb.	14¾d.
Rods Drawn	,,	12¾d.
Wire	,,	10⅞d.
*Extruded Brass	,,	6¾d.

COPPER.

Standard Cash	£67	2	6
Electrolytic	83	10	0
Best Selected	78	0	0
Tough	76	0	0
Sheets	110	0	0
Wire Bars	84	5	0
Ingot Bars	84	5	0
Solid Drawn Tubes	lb.	15d.	
Brazed Tubes	,,	15d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	£0	3	4½
‡Ferro Tungsten	,,	0	3	1½
Ferro Chrome, Basis 60% carbon, max. 2%, scale 12/- per unit	,,	32	15	0
Ferro Chrome Carbon Free	lb.	0	0	11
‡Manganese Metal 96-98% Mn	,,	0	1	3
‡Metallic Chromium	,,	0	2	7
Ferro-Vanadium 25-50%	,,	0	12	9
Ferro-Silicon 25%	ton	7	17	6
,, ,, 50%	,,	11	10	0
,, ,, 75%	,,	19	0	0
‡ ,, Molybdenum 75%	lb.	0	4	2
‡ ,, Titanium 23-25%	,,	0	0	9
,, Nickel		£170–£175		
,, Cobalt	lb.	0	9	6
,, Manganese loose		12	10	0
,, ,, Export		13	10	0
,, Phosphorus 25%		16	0	0

FUELS.

Foundry Coke—			
S. Wales Export	£1	12	6
Sheffield ,,	1	1	0
Durham	1	5	0
Furnace Coke—			
Sheffield Export	1	1	0
S. Wales ,,	1	8	0
Blast-Furnace Coke, at ovens	0	17	0

GUN METAL.

Commercial Ingots	£71	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards.. lb.	0	1	2
*Cored Bars ,,	0	1	4

LEAD.

Soft Foreign	£19	13	9
English	21	5	0

MANUFACTURED IRON.

Scotland—			
Crown Bars	£10	5	0
N.E. Coast—			
Rivets	11	10	0
Best Bars	11	5	0
Common Bars	10	15	0
Lancashire—			
Crown Bars	10	15	0
Hoops	13	0	0
Midlands—			
Crown Bars	10	7	6
Marked Bars	12	10	0
Unmarked Bars	—		
Nut and Bolt Bars	9	2	6
Gas Strip	11	2	6
S. Yorks.—			
Best Bars	11	10	0
Hoops	12	0	0

PHOSPHOR BRONZE.

*Bars, Tank brand, 1 in. dia. and upwards	lb.	1/2
*Cored Bars	,,	1/4
†Strip	,,	1/4
†Sheet to 10 W.G.	,,	1/5
†Wire	,,	1/6
†Rods	,,	1/5
†Tubes	,,	1/9½
†Castings	,,	1/4

†10% Phos. Cop. £25 above B.S.
†15% Phos. Cop. £30 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£4	1	0
Foundry No. 1	4	0	6
,, No. 3	3	18	0
N.E. Coast—			
Hematite No. 1	3	18	0
Foundry No. 1	3	15	0
,, No. 3	3	12	6
,, No. 4	3	11	6
Cleveland—			
Foundry No. 3	3	12	6
,, No. 4	3	11	6
Silicon Iron	3	15	0
Forge No. 4	3	11	0
N.W. Coast—			
Hematite	4	11	6
Midlands—			
N. Staffs Forge No. 4	3	15	6
,, Foundry No. 3	3	19	6
Northants—			
Forge No. 4	3	11	0
Foundry No. 3	3	15	0
Derbyshire Forge	3	14	6
,, Foundry No. 3	3	18	6
West Coast Hematite	4	11	6
East ,, ,,	4	9	0
Swedish Charcoal Pig	6	5	0

SCRAP METAL.

Copper Clean	£61	0	0
,, Braziery	57	0	0
,, Wire	—		
Brass	43	0	0
Gun Metal	54	0	0

SCRAP METAL—continued.

Zinc	£13	0	0
Aluminium Cuttings	65	0	0
Lead	20	0	0
Heavy Steel—			
S. Wales	3	7	6
Scotland	3	5	0
Cleveland	3	2	6
Cast Iron—			
Lancashire	3	5	0
S. Wales	2	18	6
Cleveland	3	5	0
Steel Turnings—			
Cleveland	2	13	0
Lancashire	2	5	0
Cast Iron Borings—			
Cleveland	2	10	0
Scotland	2	10	0

SPELTER.

G.O.B. Official	—		
Hard	£15	5	0
English	18	17	6
India	16	5	0
Re-melted	17	0	0

STEEL.

Ship Plates (Scotland)	£8	15	0
,, ,, (N.E Coast)	8	15	0
Boiler ,, (Scotland)	10	0	0
,, ,, (N.E. Coast)	10	0	0
Sheets 20 W.G.	11	15	0
Angles (N.E. Coast)	8	7	6
,, (Midlands)	8	7	6
Joists	8	10	0
Heavy Rails	8	10	0
Fish-Plates	12	10	0
Light Rails	8	17	6
Sheffield—			
Siemens Acid Billets	9	10	0
Hard Basic	9	12	6
Medium Basic	8	2	6
Soft Basic	7	0	0
Hoops	9	15	0
Manchester—			
Hoops	9	0	0
Bridge and Tank Plates	8	17	6
Angles	8	7	6

Tool Steel, High Speed—		
Finished Bars 18% Tungsten	lb.	2/9
Round and Squares, ½ in. to ¾ in.	,,	3d.
Under ½ in. to $\frac{3}{16}$ in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ¾ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	3d.

TIN.

Standard Cash	£162	15	0
English	163	15	0
Australian	167	15	0
Eastern	172	2	6
Tin Plates I.C. 20 × 14	box	18/9	
Block Tin Cash	£166	10	0

ZINC.

English Sheets	£28	0	0
Rods	32	10	0
Battery Plates	26	0	0

* McKechnie Brothers, Ltd., quoted March 11. † C. Clifford & Son, Ltd., quoted March 11. ‡Murex Limited, quoted March 12.

Pearson & Knowles' Current Basis Prices:—Wrought Iron Bars, £10 15s. 0d.; Mild Steel Bars, £8 5s. 0d. to £8 10s. 0d.; Wrought Iron Hoops, £12; Best Special Steel Baling Hoops, £9 15s. 0d.; Soft Steel Hoops (Coopers' and Ordinary Qualities), £9 to £9 5s. 0d.; C.R. & C.A. Steel Hoops, £12 10s. 0d. to £13 10s. 0d.; "Iris" Bars, £9 15s. 0d. All Nett Cash.

Catalogues and Other Publications—contd.

We have received the February issue of the *Nickel Bulletin*, which contains a very useful article dealing with nickel in electrical engineering. Another useful article refers to copper-nickel alloys for electrical resistances. These articles are in addition to the usual interesting features, and are worthy of note. The issue is available on application to Mond Nickel Co., Ltd., Imperial Chemical House, London, S.W. 1.

The Electric Resistance Furnace Co., Ltd., who are publishers of the informative pamphlet entitled "The Resistance Furnace," have forwarded a recent issue which contains very useful information respecting the "Afco" B.M. Type Resistance Furnaces. It is well illustrated, and all interested in resistance furnaces for operations covering temperatures between 500° C. and 850° C. would find a perusal of its contents very interesting. It is available on application at the offices of this company, 17, Victoria Street, London, S.W. 1.